Erratum

Page 320, line 22, *for* 12 ounces *read* 12 grains

Tissandier's Photography.

PHOTOGRAPHY

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A HISTORY AND HANDBOOK OF PHOTOGRAPHY

Translated from the French of

GASTON TISSANDIER

EDITED BY

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WITH UPWARDS OF SEVENTY ILLUSTRATIONS

LONDON
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PREFACE.

ARAGO placed the daguerreotype amongst the most remarkable conquests of genius, by the side of the telescope and the electric battery. And indeed to every enlightened mind, the fixing of the image or picture of the 'camera obscura' or dark chamber by chemical agents, must appear a great event in the history of progress. An art so novel, capable of producing at the very outset such strange results, at once stamped itself as something grand, extraordinary, as a work full of vitality and vigour.

Franklin's words with respect to the balloon, 'It is the infant just beginning to grow,' could not have been applied to the daguerreotype, which has grown and prospered with such rapidity as to have had, so to speak, no childhood or growth at all. The daguerreotype is one of the latest of the prodigies of modern science; it was discovered in 1838.

The daguerreotype, as soon as born, transformed itself into the photograph. Hardly forty years have

elapsed and the new invention has spread abroad and become so well known, that it has penetrated everywhere, in every civilised country, into the dwellings of the poor as well as of the rich. Unhappy indeed is he who cannot have recourse, for the picture of that which he loves, to photography, that sublime and beneficent art which gives us at such little cost the human visage in its exactitude, which presents to our eyes as in a mirror the scenery of distant lands, which lends its aid to all the sciences, which accompanies the astronomer into the depths of the heavens, the micrographer into the invisible world, and which even comes to the assistance of the besieged city, reducing its messages to the easy burden of a bird !

In studying the plan of this work, the author was impressed with the importance of the subject ; in writing it, he experienced a deep admiration, which it has been his aim to impart to the reader. He has endeavoured to make his sketch at once a practical guide to the amateur photographer, and an attractive and instructive history, as is that of all scientific conquests when narrated with truth and sincerity.

In this second edition which follows so closely on the first, some gaps, which the development of the art rendered in some degree inevitable, have been filled up from the large number of new facts which have come to light.

G. T.

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PART I.

THE HISTORY OF PHOTOGRAPHY.

CHAPTER I.

THE ORIGIN OF PHOTOGRAPHY.

J. B. PORTA AND THE DARK ROOM—FABRICIUS THE ALCHEMIST—LUNA CORNEA—PROFESSOR CHARLES' SILHOUETTES—WEDGWOOD, HUMPHRY DAVY, AND JAMES WATT.

THE discovery of photography ranks amongst the most wonderful applications of modern science; we owe it almost solely to the genius of Niepce and Daguerre. We shall mention the obstacles which these great minds had to overcome before solving a problem which had long been looked upon as Utopian; we shall thus see with what perseverance the inventor must arm himself to attain his ends. But before relating facts we think it would be useful to look a little farther into the past to seek their causes. Nothing is more instructive than the impartial history of great discoveries; it shows us how slow is the march of progress, and how many beacons

must shine along the course of centuries to guide the inventor into the region of the unknown. First appears a man who sows the germ, others follow and cultivate it, up to the time when some genius fertilises and renders it fruitful.

The germ of photography is the dark room (or camera obscura), discovered in the second half of the sixteenth century by J. B. Porta, a clever Italian philo-

Fig. 1.

THE DARK ROOM.

sopher. The process which the illustrious Neapolitan employed was most simple. He made an aperture, hardly large enough to admit the little finger, in the shutter of a window so perfectly closed as entirely to exclude light. The rays of light penetrating through the circular hole into the dark room were projected on to a white screen, on which they depicted the reversed

image of exterior objects. (Fig. 1.) The simple observation of Nature might have led at once to this dis-

Fig 2.

THE IMAGE OF THE SUN FORMED ON THE SHADOW OF A TREE.

covery. The foliage of trees does not entirely intercept the sun's light, it often allows rays of light to pass

through the spaces which exist between the leaves, and the images of the ruler of the day appear as luminous discs in the midst of the well-defined shadows on the ground. (Fig. 2.) It is easy to reproduce this phenomenon by passing the light of a candle across a small orifice, and projecting it on to a screen, on which a reversed image of the flame will be seen.

Porta, in his treatise on 'Natural Magic,' goes into raptures, and excusably, over his discovery, of which he seems to have foreseen all the future importance; he describes it with irrepressible admiration, and after describing it, exclaims with enthusiasm, 'We can discover Nature's greatest secrets!'

And truly, indeed, must those have wondered whom Porta initiated into the mysteries of his dark room! With what bewilderment would they not contemplate this sharp, lifelike, and delicate picture, drawn by the light on a screen, which was thus transformed into a faithful mirror!

Soon, by means of a convex lens, fixed in the aperture in his shutter, and by the aid of a glass mirror which reversed the image, Porta was enabled to contemplate the representation of exterior objects no longer reversed, but in their natural positions. Porta lost no time in recommending the use of the dark room to all

painters desirous of obtaining exact and minute delineation, and shortly afterwards Canaletto profited by his advice and employed the invention for taking his ad mirable views of Venice.

What would the Neapolitan philosopher and the Venetian painter have said had they been told that this image of the dark room would one day draw itself, not merely fugitively, but that it would print itself on a glass moistened with chemical agents, that it would transform itself into a durable picture, only to be compared for exactness to the reflection of a mirror? This wonder was, indeed, to be accomplished unknown to Porta; but his work was not in itself sufficient to conduct science to such a result, numerous labourers had also to add their stone to the edifice.

To find another of the original principles of photography we must quit Naples and transport ourselves to France, and to a little earlier epoch, when alchemy seemed to have attained its utmost development. It was in the middle of the sixteenth century that the action of light on the nitrates of silver was accidentally discovered by an alchemist.

The few isolated observations which had been made up to this time were very incomplete and little known. The Greeks knew that the opal and amethyst lost their

brilliance if exposed to the lengthened action of the solar rays. Vitruvius had noticed that the sun altered and changed certain colours used in painting, and therefore always placed his pictures in rooms with a northern aspect. But such observations as these can hardly be considered as the results of scientific study.

The alchemists have often been the subject of calumny. Though it is true that amongst the adepts in the 'Black Art' there were numerous charlatans and quacks, it must not be forgotten that a large number of the philosophers of the middle ages, men of indefatigable research, were possessed with a real love of their art; which they cultivated if not with method at least with invincible perseverance. It was one of these laborious workers who first produced chloride of silver, and recognised the important property possessed by this substance of becoming black under the action of light.

This disciple of Hermes was named Fabricius. One fine day, buried probably in the confusion of his laboratory, after having conjured up the devil and all the imps of darkness, after having in vain ransacked the books of magic, which swarmed in the middle ages, for the formula of that panacea which was to prolong life, cure all ills, and transmute the metals, he threw some sea salt into a solution of nitrate of silver and obtained

a precipitate (chloride of silver) to which the alchemists of those times gave the name of 'Luna cornea,' or 'horn-silver.' He collected it, and what was his astonishment when he perceived that this substance, as white as milk, became suddenly black as soon as a ray of sunlight fell on its surface!

Fabricius continued to study this remarkable property, and in his 'Book of the Metals,' published in 1556, he relates that the image projected by a glass lens on to a surface of 'Luna cornea' imprinted itself in black and grey, according as the parts were completely illuminated, or touched only by diffused light. But here the alchemist stopped; this fact, so full of significance, remained a dead letter in his hands. The science of those times, powerless through want of method, ignored the art of inferring from observation, and of confirming by experiments the deductions thus obtained. The chemists of this epoch could not see because their eyes had not been trained to look; they let the fact escape and pursued the fancy; like the dog in the fable, they abandoned the substance to grasp the shadow. What did it signify to Brandt if he discovered phosphorus, to Basile Valentin if antimony issued from his crucibles, to Albert the Great if nitric acid was distilled in his retort? all this, to these preoccupied minds, was not the philoso-

pher's stone. They did not deem it worth while to stop at such inventions. They passed on, and condemned themselves to wander in labyrinths without issues, they travelled through life as if impelled by fate towards a chimerical goal, which they could never reach. They groped along regardless of the great opportunities with which chance strewed their path, and did not even stoop to lift the gems which good fortune threw in their way!

Fabricius missed the principle of one of the most astonishing arts of modern times. Why was he not struck with some sublime presentiment, of which genius seems to have the secret? why was he not suddenly seized with one of those fortuitous inspirations which seem to be the birthright of true genius?

It was thus that, in 1760, a fantastical writer, though not a Fabricius, nevertheless divined photography. If Cyrano de Bergerac, born two centuries before balloons, may be considered as an aëronaut, Tiphaine de la Roche may be equally regarded as a photographer. This Tiphaine was a native of Normandy and a great lover of eccentricities; he has left us a whimsical book in which there is much that is astonishing, buried though it is in an indescribable medley of nonsense. In one of the chapters of this

curious old book he relates how he was caught up in a hurricane and deposited in the domain of the genii, who initiated him in the secrets of Nature. 'You know,' said one of them to Tiphaine, 'that rays of light reflected from different bodies form pictures, paint the image reflected on all polished surfaces—for example, on the retina of the eye, on water, and on glass. The spirits have sought to fix these fleeting images;[1] they have made a subtle matter by means of which a picture is formed in the twinkling of an eye. They coat a piece of canvas with this matter, and place it in front of the object to be taken. The first effect of this cloth is similar to that of the mirror, but by means of its viscous nature the prepared canvas, as is not the case with the mirror, retains a facsimile of the image. The mirror represents images faithfully, but retains none; our canvas reflects them no less faithfully, but retains them all. This impression of the image is instantaneous. The canvas is removed and deposited in a dark place.

[1] This recalls a Chinese tradition which accords to the sun the power of photographing a landscape on a sheet of ice. An ancient sage, it is said, discovered a picture of the trees and shrubs on the banks of a stream engraven on its frozen surface. It seemed as if the reflected image were caught and frozen on the ice. But this early example of photography, if it ever existed at all, may have been produced by a powerful gleam of the hot sun of North China tracing the outlines of shadows thrown across a dark surface of ice thinly covered with snow.—ED.

An hour after the impression is dry, and you have a picture the more precious in that no art can imitate its truthfulness.'

In writing these truly prophetic lines, had Roche no knowledge of the book of Fabricius, or rather had he not himself experimented with Porta's dark room, in supposing, as though in a dream, that the fleeting reflection had been fixed for ever? We cannot say. But however that may be, to find really serious and scientific studies we must come down to the end of the eighteenth century—to that period, the most surprising perhaps in the history of progress, when the gloom of the past dispersed, when light appeared, when the savant rubbed his eyes and for the first time looked around him.

In 1777, Scheele, the great Swedish chemist, discovered that chloride of silver is much more sensitive to blue and violet rays than to those of a green and red colour. About the year 1780, Professor Charles, the inventor of the hydrogen gas balloon, made the first use of the dark room for attempting to produce rudimentary photographs. He exhibited to the numerous and attentive audience at his course of lectures on natural science a curious, and at that time even wonderful experiment. By means of a strong solar ray, he projected a shadow of the head of one of his pupils

FIG. 3

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PROFESSOR CHARLES' EXPERIMENT.

on to a sheet of white paper which had previously been soaked in a solution of chloride of silver. Under the influence of the light it was not long in becoming black in the parts exposed, remaining white on that portion of the sheet which had been shaded, and thus giving a faithful silhouette of the person's head in white on a black ground. (Fig. 3.[1]) This sheet of paper, which seemed as though endowed with magical properties, was passed from hand to hand; but soon the light acting on the silhouette till then white, blackened it like the ground, and the profile disappeared little by little as though blotted out with ink.

Professor Charles also reproduced, roughly, it is true, some engravings which he placed on a sensitised paper. The details of this experiment are, however, for the most part wanting in the historical documents relating to his works.

Wedgwood, a clever English scientist, made a similar experiment to Professor Charles'; he projected the image

[1] Our illustration of this curious experiment of the celebrated chemist is based on the rather vague and incomplete accounts which were given of it at the time of its exhibition by Professor Charles. We suppose in our engraving that the experiment is just commencing; the silhouette of the person is in black; a few moments later, the part of the paper represented as white will become black, and, when the person retires, it is his shadow seen in black, which appears in white because the light could not affect this part of the silvered paper.

of the dark room on to a sheet of paper similarly sensitised, and obtained a rough picture, which could only be preserved in the dark. In 1802 Wedgwood and Sir Humphry Davy published a remarkable treatise on the reproduction of objects by light.[1]

James Watt, the celebrated inventor of the steam engine, also studied this singular phenomenon; and the problem of fixing the image of the camera occupied his great mind for some time; but the results he obtained were doubtless insignificant, for he does not refer to them at all in his writings. It was much the same with the great English chemist, Humphry Davy, who has left us a few lines on the subject of Wedgwood's experiment.

'All that is wanting,' said he, 'is a means of preventing the lights of the picture from being afterwards coloured by daylight; if this result is arrived at, the process would become as useful as it is simple. Up to the present time it is necessary to keep the copy of the picture in the dark, and it can only be examined in the shade, and then but for a short time. I have tried in

[1] This method was also employed to delineate profiles, or shadows of figures, the woody fibres of leaves, wings of insects, &c. Chloride of silver in a wet state was found to be more susceptible to the influence of light than nitrate of silver. Pictures produced at this time could not be fixed.—ED.

vain every possible method of preventing the uncoloured parts from being affected by the light. As for the images of the dark room, they were doubtless not sufficiently illuminated to enable me to obtain a visible picture with the nitrate of silver. It is that, nevertheless, which is the great point of interest in these experiments. But all attempts have been fruitless.'

The problem which Davy thus clearly describes, and which neither Charles, Wedgwood, Watt, nor himself could solve, was destined to be overcome by two Frenchmen, whose names ought to be reckoned amongst the glories of the national genius.

CHAPTER II.

DAGUERRE.

DEGOTTI THE SCENE-PAINTER—EARLY LIFE OF DAGUERRE—INVENTION OF THE DIORAMA—THE CAMERA OR DARK ROOM—CHEVALIER THE OPTICIAN—THE HISTORY OF AN UNKNOWN—FIRST LETTER OF DAGUERRE TO NIEPCE.

AT the commencement of the present century there was at Paris a scene-painter of the name of Degotti, who painted the finest scenes of the Grand Opera. At his celebrated studio this master produced truly wonderful pictures. He taught numerous pupils who by their natural disposition were drawn more towards independence of colour and freedom of pencil than towards the school of the Academy. One of the followers of Degotti soon signalised himself by his rare talents; he attacked the canvas with the ardour of an artist thoroughly imbued with the grand effects of painting. The name of this promising débutant was Daguerre.

Daguerre was born in 1787 at Cormeilles near Paris.

In the midst of the political paroxysms and cataclysms of the great Revolution his childhood was singularly neglected. Arrived at a suitable age, his parents allowed him to make his own choice of a profession. The youthful Daguerre gladly chose the career of an artist. From his tenderest childhood, as soon, indeed, as he could hold it between his fingers, he had exhibited a wonderful facility with the pencil. He excelled in rendering with fidelity the most difficult effects of the boldest perspective, he studied especially scenic effect, and he thus soon found himself at home in Degotti's studio, where he was not long in equalling and then excelling the talent of his master.

Not only was young Daguerre a genius at landscape scene-painting, the *spécialité* of scene-painters, but he could readily solve the mechanical problems relating to the mysteries 'behind the scenes,' such as fixing, shifting, &c. He substituted for the movable frames of the side scenes large canvas backgrounds on which a whole vast landscape or an entire panorama could be represented. But not content with producing a masterly picture, he conceived the idea of giving it a value until then unknown, by having recourse to the untried resources of powerful illumination. His first attempts met with unexpected success. The unknown artist of yesterday had become the pet of the Parisian populace.

At the Opera, at the Ambigu Comique, in 'The Dream,' in 'The Wonderful Lamp,' in 'The Vampire,' the scenes of the new painter had an immense success every night. The papers and theatrical journals spoke of nothing but the effects of the rising moon and the setting sun ; and the name of Daguerre flew from mouth to mouth, carried by the *éclat* so resounding in Paris, especially when it celebrates anything which affects the pleasures of the public.

But Daguerre did not rest content with this ; he aimed at a more lasting fame ; his success far from elevating served only to stimulate him : he dreamt of new triumphs, and in spite of the dissipations of Parisian life, he never forgot that work and perseverance are the two levers capable of raising great results. He had doubtless to struggle with the enticements of pleasure, for his temperament was ardent and his spirits lively and imaginative. Educated in the midst of art studios and theatres, and naturally gay and light-hearted, he was a very 'gamin de Paris,' as several well-authenticated facts in his biography sufficiently show. Unusually agile, he was at home in all manly sports ; he excelled in throwing summersaults and feats of strength, and he would sometimes at social gatherings amuse his friends by walking on his hands with his legs in the air. It is even said

that he loved to appear *incognito* on the stage at the Opera, where his paintings excited universal admiration. He donned the costume of the ballet corps and figured in chorographical acts, amused at the applause of the public, which had not the least idea that under the dress of this dancer was hidden an inventor of genius. But these somewhat puerile amusements did not hinder Daguerre from working, and dreaming of success and fame. His ingenious and inventive mind, once entered upon the road to celebrity, would follow it, marking each of his steps with a new conquest; his invention of the Diorama excited universal enthusiasm.

July 1, 1822, saw crowds of people streaming towards a new establishment on the Boulevard. They were for the first time going to see a spectacle which was to be for many years an object of general admiration. Daguerre had entered into partnership with the painter Bouton, and together they had conceived the idea of imitating nature by means of immense sheets of canvas, the subjects on which were thrown in relief by a powerful and well-arranged system of lighting.

These Dioramic scenes represented views, interiors, and landscapes with wonderful fidelity, and with a truly surprising finish in execution. But that which especially excited the admiration of the spectators was the gradual

changing of the scenes, which appeared, so to speak, to dissolve into one another, one following another without appreciable interruption. All Paris went to see Daguerre's Diorama, and applauded the beautiful pictures of the Valley of Sarnen, of the Tomb of Charles X. at Holyrood, and of the Basilica of St. Peter. The effects produced by the dioramic canvas were as beautiful from an art point of view as they were curious as changes of scene.

One contemplated, for example, the Valley of Goldau, where fir-trees crowned as with a diadem of verdure the cottages of a humble village sleeping on the borders of a peaceful lake; then suddenly the sky became gloomy, dark threatening clouds appeared, a violent concussion shook the mountain, the avalanche descended, impetuous, terrible, it rushed on the village, burying it in ruins; to the peaceful picture of but a moment before, had succeeded a dreadful scene of falling and crashing rocks in indescribable confusion.

We are at the present day acquainted with the secrets of the Diorama, which, however, our space will not permit us to describe fully; but it played such an important part in the life of Daguerre that we cannot pass it by entirely in silence. The accompanying engraving shows the general aspect of the apparatus. We may

FIG. 4

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DAGUERRE'S DIORAMA.

add that the canvas was painted on both sides, and that as the light was thrown on the front or back—that is to say, reflected or transmitted—the one or the other picture appeared, and thanks to this ingenious artifice the spectator admired the changes of scenes so rapid and surprising.

The success of the Diorama did not content Daguerre, and a still more brilliant fortune was in store for this active and ambitious mind.

In executing his pictures, Daguerre constantly employed the camera obscura (or dark room) ; he endeavoured to reproduce faithfully the lively picture which the light after passing through the crystal of a lens traced on the screen at the back of his camera, but he felt that his art was powerless to copy such a model, that his genius strove in vain against obstacles which no painter could overcome. The dark room gave him nature to the life ; it was life, truth, and colour which he daily contemplated on his screen. 'Why,' cried he, 'cannot I retain these inimitable wonders which the sun's rays draw at the focus of my lens ? Why cannot I fix the image, engrave it for ever ?'

Thus Daguerre nourishes this fantastic dream incessantly in his brain. He has not knowledge enough to comprehend all the difficulties of such a problem, nor

is he ignorant enough to believe that its solution is an impossibility. He is acquainted with Professor Charles' experiment; he has heard talk of the shadows which imprint themselves so clearly on the sensitised paper; he feels that the first step has been taken, that a supreme effort might enable a bold mind to bridge the abyss which separates the isolated fact from the grand solution. This effort it will be his aim to accomplish. For the future he will have no rest until he can exclaim, like Archimedes, 'I have found.'

Daguerre used very often to go to the shop of Chevalier, the optician on the Quai de L'Horloge, in order to procure all the apparatus he could pertaining to the dark room.

'It was very seldom,' says Charles Chevalier himself,[1] 'that he did not come at least once in the week to our studio. As may be easily imagined, the subject of conversation did not vary much, and if now and then it digressed a little, it was only to return with fresh ardour to the arrangement of the dark room, the form of lenses, or the purity of the pictures!'

At this time Chevalier's shop was much frequented by amateurs and others who came to obtain from the optician similar information to that which Daguerre was

[1] *Guide du Photographe.* Paris, 1854.

in quest of. Chevalier mentions a circumstance which occurred at his shop in 1825, which seems to us so curious that we have felt bound to relate it, as one of the stirring chapters in the history of the fixation of the image of the camera.

One day a young man, poorly dressed, timid, miserable, famished-looking, entered the optician's shop; he approached Chevalier, who was alone, and said to him, 'You are making a new camera in which the ordinary lens is replaced by a convergent meniscus glass: what is the price?'

The optician's reply made his questioner turn yet paler. The cost of the object in question was doubtless as far above his means as if it had been equal to the riches of Peru or California. He lowered his head sadly without speaking.

'May I enquire,' continued Chevalier, 'what you intend doing with a camera?'

'I have succeeded,' replied the unknown, 'in fixing the image of the camera on paper. But I have only a rough apparatus, a deal box furnished with an object-glass; by its aid I can obtain views from my window. I wished to procure your improved camera lens in order to continue my experiments with a more powerful and certain apparatus.'

Whilst listening to these words Chevalier said to himself, 'Here is another of these poor fools who want to fix the image of the camera obscura!' He well knew that the problem engaged the minds of such men as Talbot and Daguerre, but none the less deemed it a Utopian dream.

'I know,' said he, 'several men of science who are engaged with this question, but as yet they have arrived at no result. Have you been more fortunate?'

At these words the young man pulled out an old pocket-book which was quite in keeping with his dress; he opened it and quietly drew out a paper which he placed on the counter.

'That,' said he, 'is what I can obtain.' Chevalier looked at it and could not control his astonishment; he saw on this paper a view of Paris as sharp as the image of the camera. It was not a drawing nor a painting; one might have said it was the shadow of the roof, chimneys, and dome of the Pantheon. The inventor had *fixed* the view of Paris as seen from his window.

Chevalier questioned the young man further, and the latter then drew from his pocket a vial containing a blackish fluid. 'You have here,' said he, 'the liquid with which I operate, and if you follow my instructions you will obtain like results.'

The unknown explained to the optician how he should go to work; then he retired, lamenting his hard fate which would not permit him to possess that object of his dreams, a new camera! He promised to return, but disappeared for ever.

Chevalier endeavoured to put in practice the instructions he had just received; but it was in vain that he made his experiments, he obtained absolutely no result with the liquid of his unknown visitor. It is probable that he did not operate under good conditions, and it is even possible that he omitted to prepare his sensitised paper in the dark. He waited long for another visit from the unknown, feeling somewhat remorseful at having been so reserved. He never saw him again.

The name of this poor inventor is lost. It was never discovered what became of him. It may be, alas! that an almshouse bed was his last refuge.

Chevalier related this curious episode to Daguerre, who paid little attention to it while he carelessly examined the remainder of the stranger's black liquid; his mind was too preoccupied with researches of its own to attach much value to the work of another.

It will thus be seen that the history of this unknown person is worthy of fixing the attention for a moment; for, though it was fruitless, it is but fair to mention it as

the work of a man, of genius perhaps, whom poverty has fatally condemned to oblivion!

But to return to Daguerre. We find him pursuing his researches with fresh energy. He has constructed a regular laboratory provided with all the necessary apparatus and innumerable chemicals; he studied the reagents, he experimented unceasingly, ever anxious to attain a result looked upon as chimerical by men of science. Ere long Daguerre declared that he had succeeded in fixing the fugitive image, but, nevertheless, gave no proof whatever that he had done so. In December 1825 he told everyone who would listen to him that the great problem was at last solved. 'I have seized the light,' he cried with enthusiasm; 'I have arrested its flight! The sun himself in future shall draw my pictures!'

A few days later, in January 1826, he called on Chevalier to talk of his favourite subject. 'Besides the young man I spoke to you about,' said the optician, 'I know a person in the country who flatters himself that he has obtained the same result as you. He has for a very long time occupied himself with reproducing engravings by the action of light on certain chemical agents. Perhaps you would do well to put yourself in communication with him.'

'And what is the name of my fortunate rival?' demanded Daguerre.

Chevalier wrote a few words on a piece of paper which he handed to Daguerre. On it was this address—'M. Niepce, propriétaire, au Gras, près Châlons-sur-Saône.'

A few days afterwards Daguerre addressed a letter to this stranger, which the latter, with provincial mistrust, threw into the fire as soon as he had read, contenting himself with murmuring between his teeth, 'There is another of those Parisians who would like to pump me!'[1] It was under these auspices that the relations between the two inventors commenced; they were, however, later on to unite their labours to create, as it were in common, an art which will be looked upon for centuries to come as one of the prodigies of our epoch.

[1] *History of the Discovery improperly called 'Daguerreotype,' preceded by a Notice of its real Inventor, the late M. Joseph Nicéphore Niepce*, by his Son, Isidore Niepce. Paris, 1841.

CHAPTER III.

NICÉPHORE NIEPCE.

THE TWO BROTHERS NIEPCE—THEIR YOUTH—THEIR WORKS—THE PYRÉLOPHORE—HYDRAULIC MACHINE—NICÉPHORE'S RESEARCHES IN HELIOGRAPHY—RESULTS OBTAINED.

JOSEPH-NICÉPHORE NIEPCE was born at Châlons-sur-Saône on March 7, 1765. His life and works are so interwoven with those of his elder brother Claude, to whom he was devotedly attached, that their history is a joint one, like that of the Brothers Montgolfier. We shall see them walk side by side through life, mutually sustaining and helping each other.

Their father, Claude Niepce, was steward to the Duke of Rohan-Chabot; their mother was the daughter of a celebrated barrister, Barault by name.

'Joseph and his brother Claude,' says one of their biographers, 'were brought up with great care and solicitude by their father. Their tutor was the Abbé Montangerand, a very clever man.

'... The brothers made rapid progress in lan-

guages, sciences, and belles-lettres. They had real love for learning, and being of gentle and timid dispositions, were content in themselves, not joining in the games and amusements usual to children of their age. They seemed born for the contests of the mind and intellect. Nicéphore and Claude employed their play time in constructing little machines of wood with cog wheels, with the aid of their knives only. These machines worked well, to the great joy of their makers; they imitated the raising and lowering movements of the crane.'[1]

Nicéphore Niepce, like Daguerre, like all the men of his time, had to submit to the influence of the great Revolution. On May 10, 1792, he changed the clerical dress, which he had till then worn, for the military costume, and entered as sub-lieutenant in the 42nd regiment of the line.

Young Niepce was made lieutenant on the 16th Floreal of the year I. of the Republic (May 6, 1793), and took part in the expedition to Cagliari, in Sardinia.

[1] We borrow these remarks on the life of Niepce from a remarkable and rare pamphlet by M. Victor Fouque, entitled *The Truth with respect to the Invention of Photography. Nicéphore Niepce, his Life, Essays, and Works, from his Correspondence and other unpublished Documents.* Paris, 1867. The author of this pamphlet, which excited great attention on its first appearance, has, unhappily, fallen into totally erroneous ideas with regard to Daguerre, to whom he would deny any part in the creation of photography.

The same year (1793) he figures in the ranks of the army of Italy, partaking in its glorious exploits. The 18th Ventose, year II. (March 9, 1794) he was appointed assistant to adjutant-general Frottier, shortly after he was suddenly attacked by a severe and dangerous illness, which obliged him to leave the regiment and sèek an asylum in the town of Nice. There, thanks to the care of the mistress of the house in which he lived, Madame Romero, and the devotion of her daughter Mademoiselle Marie-Agnes, he regained his health. But whilst regaining his health he had been losing his heart, which he at last offered to Miss Marie-Agnes, and they were married the 17th Thermidor of the year II. (August 5, 1794).

But the illness he had undergone had affected his constitution, and, obliged to give up his military career, he retired to Saint Roch, near Nice, where he lived with his wife and his brother Claude. It was during their stay at Saint Roch that the brothers conceived the idea of a motive power to propel ships without the aid of sails or oars. The machine which the brothers invented was put in motion by hot air; they gave it the name of the *pyrélophore*, and, as soon as they returned to their native town of Châlons, they fitted up a boat with their new apparatus and ran

it on the Saône. Later on, when the Government of the First Empire offered prizes for an improved hydraulic machine to take the place of Marly's, the brothers Niepce sent in the model of a pump which was as simple as it was ingenious, and for this new system, as also for their pyrélophore, they were thanked by the Institute.

During the Continental blockade, the Government called on men of science if possible to replace the indigo procured from abroad, and so useful in dyeing wools, by *woad*, the juice of which might in some way be employed in the art of dyeing. In answer to the appeal the brothers turned their attention to the subject, and materially helped to lay the foundation of a new culture. In the years preceding the fall of the First Empire they rendered the greatest services to France.

But the two brothers were soon obliged to separate. In 1811 Claude quitted the paternal roof at Châlons, never to return, and went to Paris. His purpose was to launch the pyrélophore, and the great town seemed to him to be the only place where his work might at length be crowned with success. But against the invincible obstacles in his way all his efforts were in vain; he failed alike in his trials and in his applications.

He left Paris and France and settled definitely at

Kew near London. The two brothers, thus separated by exigency and distance, kept up an unbroken correspondence, which M. Foque has published in his beautiful book dedicated to the memory of one of the inventors of photography. These letters are a rare example of mutual affection and solicitude, in which the ingenious conceptions of the laborious minds are as numerous as the marks of affection of tender and devoted hearts.

Living alone in his country-house at *des Gras* near Chalons, Nicéphore Niepce devoted himself assiduously to his researches, which were encouraged by the quiet country life and sweet solitude of the paternal home.

It was a simple and modest building, this cradle of photography, shaded by a few trees and situate on the bank of the Saône, which gave it a sweet and vivifying freshness. Under this humble roof, Niepce devoted ten years of his life to solving the problem of the fixing of the picture of the camera obscura.

After his numerous researches in the making of new machines, in the cultivation of woad, &c., Nicéphore turned his attention into a new direction, when lithography made its appearance in France. This great discovery of the German Aloys Senefelder was brought into France in 1802 by the Count de Lasteyrie-Dus-

saillant, who, ten years after his first attempts, founded an admirable Lithographic Institution in Paris. This new art met with universal success. Niepce partook of the general enthusiasm, became enraptured with lithography, and taught himself how to use its appliances; but, far from Paris, he could not procure proper apparatus and stones, he therefore determined to make them for himself.

'In 1813,' writes his son Isidore Niepce, 'my father made some attempts at engraving and reproducing drawings, by lithography, which had recently been introduced into France, and which attracted his admiration. Some broken stones, intended for repairing the main road between Châlons and Lyons, which came from the Quarries of Chagny, seemed to him to be suited, from the fineness of their grain, to be usefully employed in lithography. We chose some of the largest of these stones, and my father had them polished by a marble-worker of Châlons; I then made various drawings on them, which my father coated with a varnish he had prepared; he then etched them by means of an acid.

'But finding that the grain of these stones was not sufficiently fine and regular, my father replaced them by polished tin plates; he coated these plates with various varnishes, then placed on them the drawings which he

had previously varnished to render them transparent, and exposed the whole to the action of light. This was the commencement, very imperfect if you like, of heliography.'

Once on the road to discovery, Niepce continued his studies with that unwearying perseverance of which the inventor seems to have the sole monopoly.

He was not long in having recourse to the camera, but he was alone in a country far from any scientific centre, and he had to tax his ingenuity and make for himself what he wanted; he was his own cabinet-maker and optician, he manufactured his cameras and his apparatus, and as a rest from his labours took the pen and opened his heart to his dear Claude. His progress in heliography was rapid, as is proved by the following letter (a remarkable document and precious for the history of photography), dated May 5, 1818, which we reproduce entire:—

'You have seen,' he says to his brother, 'that I had broken the object-glass of my camera; but that I had another which I hoped to be able to make use of. My attempt was a failure; this glass has a shorter focus than the diameter of the box, and so I could not make use of it. We went to town last Monday; I could only find at Scotti's a lens of longer focus than the first, and I have

had to lengthen the tube which holds it, and by means of which the exact focus is adjusted. We returned here Wednesday evening; but since then the weather has always been dull, preventing me from continuing my experiments; moreover, I am too worried and fatigued with paying or receiving visits to be able to give much attention to them. I would prefer, I assure you, to live in a desert.

'When my object-glass was broken, no longer being able to make use of my camera, I made an artificial eye with Isidore's ring box, a little thing from 16 to 18 lines square. I had, luckily, the lenses of the solar microscope, which, as you know, belonged to our grandfather Barrault. One of these little lenses proved to be exactly of the focus wanted; and threw a picture of objects in a very sharp and life-like manner on to a field of thirteen lines diameter.

'I placed this little apparatus in my workroom facing the open window looking on to the pigeon-house. I made the experiment in the way you are acquainted with, my dear friend, and I saw on the white paper the whole of the pigeon-house seen from the window, and a faint impression of the window frame itself which was not exposed to the sunlight. One could distinguish the effects of the solar rays in the picture from the pigeon-house up

to the window-sash. This is but a very imperfect experiment, but the images of the objects were extremely minute. The possibility of painting by this means appears almost clear to me; and if I am able to perfect my process, I shall hasten to respond to the interest which I know you will take in it, by imparting it to you. I do not hide from myself that there are great difficulties, especially as regards fixing the colours, but with work and patience one can accomplish much. What you had foreseen has proved true. The ground of the picture is black, and the objects are white, that is to say lighter than the ground.'

In the course of his correspondence with his brother, Nicéphore continually mentions his efforts, researches, and experiments. On May 19, 1816, he says to him, 'I shall occupy myself with three things; 1st. To give more relief to the representation of the objects. 2nd. To transpose the colours [by this must, most likely, be understood, to reproduce the exact tones of nature]; 3rd and lastly to fix them, which will not be easy.' On the 28th of the same month he sent Claude four metallic plates which bore impressions produced by light. Unfortunately, it is impossible to know what substance Nicéphore used for sensitising his plates; through prudence and from fear of some indiscretion he never mentions it in any of his letters. His writings, however, show

us that whatever it was, he was not satisfied with it; for he says later on, in a letter to his brother, that he had been trying to make use of alcoholic solutions of chloride of iron. In 1817, he had recourse, in his *Heliographic studies*, as he already calls them, to chloride of silver, and then to organic matters such as *guaiacum* (a resin), and at last to phosphorus, which, as is well known, from white turns gradually to a red colour under the action of light. But he was not long in love with this new agent, which he very justly terms a 'dangerous combustible.'

On July 2, 1817, he declares that his efforts have not yet been completely successful, but he adds, without losing hope, 'I have not varied my experiments sufficiently to consider myself as beaten, and I am by no means discouraged.'

Here the interesting documents relating to the early history of photography cease for a time; no letter of Niepce's for the next nine years (1817–1826) is to be found; but it is certain that the illustrious and painstaking inventor never abandoned his researches. In 1826 we find him stopping definitely at *balm of Judæa*, a resinous substance which, when spread out thinly and exposed to the light, turns white and becomes insoluble in essence of lavender. When placed at the focus of the camera a whitish delineation of the picture

thrown on to it is obtained. In possession of this fact, which he had so patiently conquered at the price of the most persevering researches, Niepce was enabled to reproduce engravings by the action of light and fix in a transient manner the image of the camera.

As regards the first point, Niepce varnished the back of the engraving to be reproduced, thus rendering it transparent; then he placed it on a tin plate which had previously been covered with a thin coat of bitumen of Judæa. The transparent parts of the engraving, *i.e.* those which had not come in contact with the ink, allowed the light to pass through and whiten the bitumen of Judæa. A tolerably faithful copy of the engraving placed on it was thus obtained on the metal plate, which was then plunged into a bath of essence of lavender in order to dissolve those parts of the bitumen which had been protected from the light. The picture thus obtained was permanent, the light having no further action on it.

But this reproduction of engravings could only be considered as a scientific curiosity; the grand problem was the fixing of the image of the camera. Niepce laid down the first plans for its solution.

He placed at the focus of his camera a tin plate coated with bitumen of Judæa. The light whitened the resin wherever it fell on it, and rendered it insoluble in

essence of lavender. The exposed plate was plunged into a bath of the fixing liquid, which dissolved only those parts of the bitumen not affected by the light; a photograph was thus obtained in which the lights corresponded to the lights and the shadows to the shadows; the former being produced by the whitened resin, the latter by the metal laid bare by the solvent.

These metallic pictures, as may be supposed, were not of any great value; they were feeble, pale, and dull. Niepce endeavoured to strengthen the tones by exposing the plate to vapours of iodine or sulphuret of potassium; but his attempts were in vain. In his hands the new art of Heliography made no further progress; the inventor, exhausted by ten years of labour, had done his part.

Niepce's invention, important though it was, was but the germ of photography, and was subject to some grave defects. Bitumen of Judæa is a substance which is only acted upon very slowly and feebly by light. It was necessary to expose the metal plate in the camera for more than ten hours; the sun displaced the lights and shades during this long space of time, the picture was therefore wanting in sharpness and definition.

Niepce's chief aim was to apply his discovery to tho reproduction of engravings; he succeeded in etching

with an acid those parts of his plates not protected by the resinous coating which had been rendered insoluble by the action of the light, and was thus enabled to produce a plate for printing from as in the copperplate press. He thus invented Heliography, and during his lifetime an artist named Lemaître published some truly remarkable prints by this ingenious process.

But the apparatus which Niepce had to work with was imperfect; his cameras were roughly and badly made, his lenses were greatly inferior to those of the present day; in spite of his fertile imagination, in spite of his unceasing toil, the boldness of his conceptions, and his indomitable perseverance, this great 'working man' of science could do no better with such poor tools. Niepce, we repeat, went no farther. Perhaps he did unwisely in abandoning the salts of silver which his predecessor had employed, perhaps he occupied himself too exclusively with the reproduction of drawings, but, however it may have been, it is certain he had not the slightest idea of the *developing agents*, i.e. the substances used at the present time for the purpose of making the latent picture, which has been mysteriously printed on the photographic plate, gradually appear. Some writers have, indeed, unjustly endeavoured to deprive Daguerre of the glory which is rightly his, as we shall see, in the in-

vention of photography, in ascribing it solely to Niepce. Whilst recognising the latter as a great mind and according him all the marks of admiration which are his due, let us not separate his name from that of his future associate, Daguerre. The inventor of the Diorama would perhaps have done nothing without a predecessor, but he far surpassed the work of Niepce. If Daguerre did not conquer his America until another had pointed out the way he should follow, he had at least the glory of following to the very end this road bristling with barriers and impediments.

The history of photography has been handled by some writers with regrettable prejudice; their sincerity we are far from suspecting, but they have certainly allowed themselves to wander from the truth, probably because, without sufficient scientific knowledge, they were incapable of rightly understanding even the principles of photography. To add to Niepce's fame they have tried entirely to suppress the name of Daguerre in the history of the art. We believe we are keeping within the bounds of strict impartiality in repeating that the names of Niepce and Daguerre should be placed together; each of these great minds has had its part in the work we are studying.

CHAPTER IV.

THE NIEPCE–DAGUERRE PARTNERSHIP.

CORRESPONDENCE EXCHANGED BETWEEN THE TWO INVENTORS—DISTRUST AND RESERVE OF NIEPCE—HIS JOURNEY TO PARIS—HIS INTERVIEWS WITH DAGUERRE—HIS JOURNEY TO LONDON—ACT OF PARTNERSHIP—DEATH OF NIEPCE.

WE have seen with what mistrust the first letter from Daguerre to Niepce was received by the latter. The inventor of the Diorama allowed almost a whole year to pass without giving further attention to the matter, but at the end of January 1827 he again wrote to Niepce, telling him explicitly that he was engaged in fixing the image of the camera, and that he had arrived at important though very imperfect results. He solicited a mutual exchange of the secrets of which each was in possession. On receipt of this request, Niepce, without abandoning his prudent reserve, and after making enquiries about Daguerre of Lemaître (whom he had entrusted with the working of his heliographic plates), and after receiving a favourable reply from that celebrated engraver, wrote as follows to the Parisian painter :—

'MONSIEUR DAGUERRE,

'I received yesterday your reply to my letter of the 25th January, 1826. For the last four months I have been unable to work; the bad weather entirely preventing me. I have perfected in an important degree my process for engraving on metal, but the results obtained not having as yet furnished me with sufficiently correct proofs, I am unable to comply with your wish. This I regret more for myself than for you, Sir, as your process is very different, and promises you a degree of superiority of which engraving will not admit; this, however, does not hinder me from wishing you all imaginable success.'

It will be seen that Niepce, strong in his work, refuses as yet to disclose his secrets. This industrious and persevering genius knew the difficulties of the problem, and believed that no one was better able to solve them than himself. The compliments which he pays Daguerre evidently hide a little delicate irony under their prudent laconicism.

But Daguerre would not be repulsed. Anxious to become acquainted with the processes of the experimenter of Châlons, he sent him a picture resembling a sepia drawing done by a process of his own. This fact is

confirmed by a letter which M. Foque reproduces in his interesting historical work.

'I forgot to tell you in my last letter,' writes Niepce to Lemaître, the engraver, under date of April 3, 1827, 'that M. Daguerre has written to me and sent me a little picture very elegantly framed, done *à la sepia*, and finished by his process. This drawing which represents an interior, is very effective, but it is difficult to determine exactly what is the result of the process as the pencil has intervened. Perhaps you, Sir, are already acquainted with this kind of drawing, which the inventor calls *smoked pictures*, and which are for sale at Alphonse Giroux's.

'Whatever may have been Monsr. Daguerre's intention, as one good turn deserves another, I have sent him a tin plate lightly etched by my process, choosing as the subject one of the engravings which you sent me. This communication cannot in any way compromise my discovery.'

Shortly afterwards Daguerre received a little case from Châlons containing a tin plate engraved by Niepce's heliographic process. But the prudent Nicéphore had taken care to wash the proof so thoroughly that not the slightest trace of the bitumen of Judæa was to be found on it. This engraving was, however, as Niepce himself

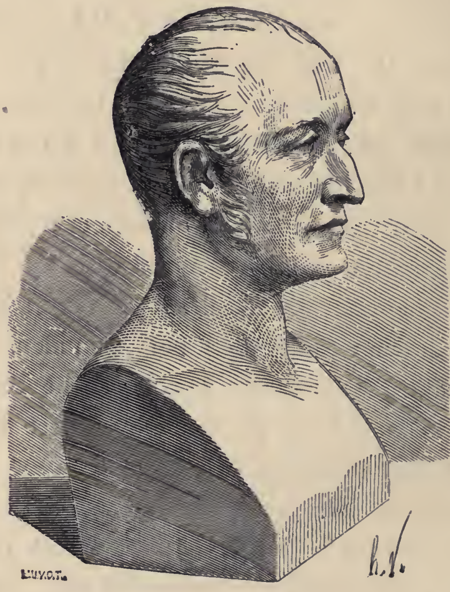
says, very defective, and much too feeble. 'I expect, Sir,' adds the inventor of heliography, 'that you have followed up your former attempts ; you were succeeding too well not to go on ! We are occupied with the same object, we should find an equal interest in our mutual efforts to attain the same end. I shall hear with much pleasure that the new experiment which you were to make with your improved camera has been successful as you expected. In that case, Sir, and if it is a fair offer, for my part I shall be as desirous of knowing the result as I shall be flattered to offer you such of my researches of a similar nature as I am occupied with.'

It will be seen that the two inventors are being gradually drawn together by a bond of union. Here is Niepce making an offer to Daguerre ; he consents to give him his secrets in exchange for those which the latter may have to impart.

But an event was about to occur which would bring these two geniuses together. In the month of August 1827, Nicéphore received intelligence that his brother Claude was seriously ill, and that his life was in danger. Nicéphore, accompanied by his wife, started for England ; he had to pass through Paris, and being unexpectedly detained there some days, he took advantage of his stay in the capital to see Lemaître and Daguerre. The

details of his curious interview with the inventor of the Diorama are preserved to us in a very interesting letter, which we do not hesitate to reproduce entire.

Fig. 5.



JOSEPH NIEPCE.

'I have had,' writes Niepce, on September 4, 1827, to his son Isidore, 'several long interviews with M. Daguerre. He came to see us yesterday, and stayed three hours; we are to visit him again before we leave,

and I don't know how long we may stay, as it will be for the last time, and we cannot find enough to say on the interesting subject of our interviews.

'I can only repeat to you, my dear Isidore, what I said to M. de Champmartin. I have seen nothing here which has given me more pleasure than the Diorama. M. Daguerre himself conducted us there, and we were able to contemplate at our ease the most magnificent views. The view of the interior of St. Peter's, at Rome, by M. Bouton is certainly admirable and perfect in its illusion. But none are finer than the two scenes painted by M. Daguerre; the one of Edinburgh by moonlight at the time of a fire; the other of a Swiss village taken from the entrance of the main road and opposite a prodigious mountain, covered with eternal snows. These representations are so faithful even in the most insignificant details, that one seems to see wild and savage nature, with all the enchantment which is lent it from the charms of colour and the magic of light and shade. The illusion is even so complete that one is tempted to leave one's seat and cross the plain to clamber to the summit of the mountain. This I assure you is not the least exaggeration on my part. The objects either were or appeared to be of their natural size. They are painted on a canvas or taffeta covered with a

varnish having the drawback of sticking, which necessitates care when these species of decorations have to be rolled for transport, as it is difficult in unrolling to avoid tearing.

'But to return to M. Daguerre. I told you, my dear Isidore, that he persists in thinking I am farther advanced than he in the researches in which we are engaged. What is at least plain now is that his process and mine are totally different. His has something marvellous about it, and a celerity of action comparable to the electric fluid. M. Daguerre has succeeded in fixing on his chemical substance some of the colours of the solar spectrum; he has already united four and hopes to obtain the other three, and thus to have the complete spectrum. But the difficulties he encounters increase in proportion to the modifications which the substance itself must undergo in order to be able to retain several colours at the same time; a great hindrance, and one which foils him completely, is that totally opposite effects are produced by these combinations. Thus a blue glass, which produces a deeper shade on the said substance, produces a clearer tint than the part exposed to the direct action of light. Then again in this fixing of the primary colours the results obtained are so feeble that the fugitive tints are invisible in broad daylight; they can

only be seen in an obscure light, and for this reason: the substance in question is of the nature of Bolognese stone (sulphate of barytes) and pyrophorus; it is very readily acted upon by light, but cannot retain the effect, because a somewhat prolonged exposure to the action of the sun ends by decomposition. M. Daguerre himself does not pretend to fix the coloured representations of objects by this process; even if he succeeds in surmounting all the obstacles in the way, he will only be able to make use of it as a sort of intermediary means. From what he has said to me, he seems to have little hope of succeeding, and his researches will hardly have any object but pure curiosity. My process appears to him to be certainly preferable, and much more satisfactory as regards the results which I have obtained. He is sensible how interesting it would be to obtain pictures by aid of a process equally simple, easy, and expeditious. He wishes that I should make some experiments with coloured glass in order to see if the impression produced on my substance is the same as that on his. I shall procure five of these from Chevalier, who has already made them for M. Daguerre. The latter insists principally on rapidity of action in the fixation of the pictures; a very essential condition indeed, and which must be the first object of my researches. As regards

the method of engraving on metal, he is far from depreciating it; but as it would be necessary to retouch and to deepen the impressions, he thinks that this process would succeed only very imperfectly for views. He thinks that for this sort of engraving the employment of glass and hydrofluoric acid would be much preferable. He is convinced that lithographic ink, carefully applied to the surface bitten by the acid, would produce on a white paper the effect of a good proof, and would moreover have a certain originality about it which would be still more attractive. The chemical composition employed by Daguerre is a very fine powder which does not adhere to the surface on which it is spread, and must therefore be kept horizontal. This powder on the least contact with light becomes so luminous that the camera is quite lit up by it. This substance, as far as I can remember, is very analogous to sulphate of baryta (cawk), or Bolognese stone, which also has the property of retaining certain prismatic rays. . . .

'Our places are taken for Calais, and our departure is definitely fixed for next Saturday at eight in the morning. We were unable to secure the places earlier, the King's journey to Paris having attracted many people in that direction.

'Adieu—our best love to Jenny, yourself, and the youngster.'

Nicéphore, on arriving in England, found his brother Claude dangerously ill, enfeebled by work, and his mind affected through over-study. He remained some weeks at Kew, and made the acquaintance of a distinguished Englishman, Sir Francis Baur, who undertook to lay the results of his heliographic researches before the Royal Society of London. But Niepce would not reveal his discoveries, and the learned English Society accepts no communication from an inventor who keeps his processes secret.

Nicéphore soon returned to Châlons and kept up a lively correspondence with Daguerre, ending by a proposal to enter into a partnership with him. After much hesitation and many delays, the inventor of the Diorama at length visited Niepce at Châlons, and there they signed an agreement.

In accordance with this agreement Niepce and Daguerre were mutually to acquaint each other with their processes. They were to work out and improve these processes in common, and together attain the object of their labours, viz., the fixation of the image of the camera. The company thus formed was to go by the name of the Niepce-Daguerre; its place of business was at Paris; and the proceeds of working the new discovery were to be divided between the two partners.

After signing this agreement Niepce acquainted Daguerre with the processes which he employed in preparing his heliographic plates. Feeble indeed was the result, as we have already seen. But the inventor of the Diorama had even less to give for the little he received. He returned to Paris after seeing Niepce's apparatus in action, resolved to work without ceasing until success crowned his efforts.

'Suddenly,' says Charles Chevalier, 'Daguerre became invisible. Shut up in a laboratory which he had had constructed in the Diorama building, where he resided, he set to work with fresh ardour, studied chemistry, and for nearly two years lived almost continuously in the midst of books, assay crucibles, retorts, and melting pots. I have caught a glimpse of this mysterious laboratory, but neither I nor anyone else was ever allowed to enter it. Madame Daguerre, Messrs. Bonton, Sébon, Carpentier, etc. can bear witness to the truth of these recollections.'[1]

In the midst of his researches and experiments, Daguerre was at last favoured with one of those accidents which often happen to the persevering worker. He had left a silver spoon on a metal plate which had been

[1] *Guide du Photographe* (*Souvenirs Historiques*).

treated with iodine, what was his surprise to find on lifting the spoon that its image was clearly and sharply imprinted on the iodised surface!

This observation was a precious revelation to Daguerre. He abandoned the bitumen of Judæa, and substituted for it iodide of silver, which darkens with wonderful rapidity under the action of light. To make his preparation, he exposed a silvered plate to the influence of vapours of iodine, and he thus obtained a surface which impressed itself with the picture thrown on it by the lens of the camera. But the plate only presented a faint shadowy image of the picture which existed still in a latent state; after trying numberless chemical substances and agents of every description, Daguerre at last discovered that petroleum oil possessed the property of developing the image on his plate. This discovery was a great step towards success; Daguerre had put his hand on a developing agent. He did not rest content here, but went on unceasingly, and at last substituted for petroleum oil the vapours of mercury, causing the invisible image which the light had printed on the iodised silver plate, to appear as if by magic and with marvellous distinctness.

Photography was henceforth a fact. Daguerre had not failed to write to his partner: he told him of his

having made use of iodide of silver, but Niepce did not believe in the efficacy of this substance. Before learning the almost definite results which Daguerre had obtained, he was seized with congestion of the brain and died July 5, 1833.

CHAPTER V.

THE DAGUERREOTYPE.

DAGUERRE'S RESEARCHES AND STUDIES—HE CEDES HIS INVENTION TO THE STATE—ARAGO AND THE DAWN OF PHOTOGRAPHY—A BILL LAID BEFORE THE HOUSE—REASONS FOR ITS BEING PASSED—MEETING OF THE ACADEMY OF SCIENCES, AUGUST 10, 1839.

DAGUERRE is thus left alone to solve the problem—a task which, in spite of its many difficulties, he had determined to accomplish. The ingenious artist has discovered a fact full of promise; he has seen that the image, traced so to speak in a latent state by the light on a plate coated with iodised silver, gradually reveals itself, that is to say becomes visible and manifest, when exposed to the action of vapour of mercury. The inventor held in his hand the thread which would conduct him in the labyrinth of his enquiries; he was no longer working in the dark, for he was in possession of the guide which would lead him to the light.

But the days and months passed in continual labours, and it was only at the price of two years entirely devoted to

toil that Daguerre at last perfected the beautiful art which was to immortalise his name.

In 1835, Daguerre was in a position to acquaint Isidore Niepce, son of Nicéphore, with the improvements which he had effected. It was time to publish the discovery of heliography. An additional clause was added to the before-mentioned agreement. Two more years were passed in constant toil and study. At length in 1837, Daguerre and Isidore Niepce signed a regular act of partnership and endeavoured to start a company to work the new discovery.

On March 15, 1838, the subscription was opened ; but the incredulous public did not respond to the call ; funds were not forthcoming ; capitalists seemed to run away from the new art of photography.[1]

[1] To give a true idea of the impression which the appearance of the Daguerreotype produced, we give almost entire an article which appeared in the *Moniteur Universel* of January 14, 1839; at this time, the results obtained by Daguerre were already known, and were the universal theme in all the papers.

'The discovery of M. Daguerre,' says the writer of the article, 'has been for some time past a subject of some wonderful accounts. . . . . After fourteen years of research M. Daguerre has succeeded in fixing the natural light on a solid surface, in giving a body to the impalpable and fugitive image of objects reflected in the retina of the eye, in a mirror, in the apparatus of the camera obscura. Figure to yourself a glass which after receiving your image presents you your portrait, as indelible as painting, and much more faithful.

'What is the inventor's secret? What is the substance endowed with such astonishing sensibility as not only to become penetrated with light, but

Daguerre then decided to cede his invention to the State. He addressed himself to several men of science and knocked at Arago's door. The illustrious astronomer and man of science was thunderstruck at first sight of the Daguerreotype plate, and was boundless in his expressions of admiration. The inventor had found his

also to retain the impression, thus operating at the same time like the eye and like the optical nerve, like the material instrument of the sensation and like the sensation itself? Indeed we cannot say. M. Arago and M. Biot, who have read reports on the effects of M. Daguerre's discovery, have declined to define their causes. By the courtesy of the inventor we have been able to examine his *chefs-d'œuvre*, in which Nature herself is drawn.

'Each picture placed before us called forth some admiring exclamation. What fineness of touch! what harmony of light and shade! what delicacy! what finish! . . . . With a magnifying glass we can see the slightest fold in a stuff, the lines of a landscape invisible to the naked eye. . . . . In a view of Paris we can count the paving stones—we see the dampness produced by rain; we can read the name on a shop. All the threads of the luminous tissue have passed from the object into the image.'

A little further on the writer indulges in a singular supposition:—

'M. Daguerre,' he says, 'has as yet only made experiments at Paris, and these experiments, even under the most favourable circumstances, have always taken so much time as only to enable him to obtain complete results of nature inanimate or at rest, movement escapes him or only leaves vague and indefinite traces. It is presumable that an African sun would give him instantaneous autographs of nature in action and in life.'

The author concludes with more sensible remarks:—'The discovery, as far as at present developed, to judge from the results which we have seen, promises to be of great importance to art and science. Some persons seem to be afraid that it will leave nothing for draughtsmen, and perhaps even for painters, to do. It seems to us that it can only prove prejudicial to the copyist. We have never heard that the invention of moulding on nature has put the genius of the sculptor in the shade. The discovery of printing did serious injury to the scribes, but not to the writers.'

advocate. Arago sent him to Duchâtel, the then Home Minister, who offered Daguerre and Isidore Niepce life pensions (modest enough !) in exchange for their secrets.

On June 15, 1839, Duchâtel laid before the House a bill relating to the new discovery, preceded by the following reasons for its acceptance :—

'You all know, and some among you have already been able to prove for yourselves, that after fifteen years of persevering and costly research, M. Daguerre has succeeded in fixing the image of the camera, and of thus creating, in four or five minutes by the aid of light, drawings in which the objects preserve their forms, even to the slightest detail, in which linear perspective and the degradation of tone produced by aerial perspective are reproduced with a delicacy hitherto unknown.

'It is not necessary to dwell upon the utility of such an invention. It will easily be understood what new facilities it must offer for the study of the sciences ; and as to the arts, the services it can render to them are incalculable.

'These reproductions so true to nature would be a constant object of study to artists and painters, even the most talented ; and on the other hand, this process offers them a ready and easy means of forming collections of studies which, if they made themselves, they could only

obtain at the cost of much time and labour and in a much less perfect manner.

'The art of the engraver would take a new degree of interest and importance, when employed to reproduce and multiply these pictures drawn by Nature herself.

'Finally, to the traveller, to the archæologist, as well as the naturalist, the apparatus of M. Daguerre would become a continual and indispensable necessity. It will enable them to fix their impressions without having recourse to the hand of a stranger. Every author would become his own illustrator; he would halt a few seconds before the most extensive view, and obtain on the spot an exact facsimile of it.

'Unfortunately for the inventors of this beautiful discovery, they find it impossible to make a matter of business of it, and to indemnify themselves for the sacrifices which were necessitated by such numerous attempts so long fruitless.

'Their invention is not one which can be protected by a patent. As soon as it is known, anyone can make use of it. The most awkward person will be able to make pictures as exact as a practised artist. It thus follows that this process must belong to all the world or remain unknown. And what just regrets would not be expressed by all the lovers of art and science if such a

secret remains impenetrable to the public, if it must be lost and die with the inventors!

'In such an exceptional circumstance it behoved the Government to intervene. It is for it to put society in possession of the discovery which it demands to enjoy in the general interest by giving to its authors the price, or rather the recompense, of their invention.

'These are the motives which have led us to conclude a provisional agreement with Messrs. Daguerre and Niepce, for which the object of the bill we have the honour to lay before you is to ask your sanction.

'Before acquainting you with the bases of this treaty, it will be necessary to give a few more details.

'The possibility of transiently fixing the image of the dark room has been known for the last century; but this discovery promised no useful results; the substance on which the solar rays pictured the image had not the property of retaining it, and became completely black as soon as exposed to the light of day.

'M. Nicéphore Niepce invented a means of rendering these pictures permanent. But, although he had solved this difficult problem, his invention still remained very imperfect. He could obtain only the outline of objects, and he required at least twelve hours to obtain the slightest drawing.

'It was by totally different means, and by putting aside the traditions of M. Niepce, that M. Daguerre has been able to arrive at the admirable results which we

Fig. 6.

DAGUERRE.

have witnessed, namely, the extreme rapidity of the operation, the reproduction of aerial perspective, and all the play of light and shade. M. Daguerre's method is his own ; it belongs to him alone, and is distinguished from

that of his predecessor as much in its cause as in its effects.

'At the same time, as before the death of M. N. Niepce an agreement was made between him and M. Daguerre, by which they engaged to share mutually all the advantages they might receive from their discoveries, and as this stipulation has been extended to M. Isidore Niepce, it is impossible to treat alone with M. Daguerre, even respecting the process which he has not only perfected but invented. It must not be forgotten, moreover, that M. Niepce's invention, although it is still imperfect, is perhaps susceptible of being improved and of being employed usefully under certain circumstances; it is therefore of importance to history and science that it should be published at the same time as that of M. Daguerre.

'These explanations will show you, Gentlemen, for what reason and by what title Messrs. Daguerre and Isidore Niepce are made parties in the agreement which you will find annexed to the bill.'

After reading this document, which, believing impartiality cannot be too strictly adhered to in history, we have thought it our duty to reproduce entire, the Home Minister read the bill which assigned a life pension of 6,000 francs a year to M. Daguerre, and to Isidore

Niepce a life pension of 4,000 francs a year, the half of each pension being reversionary to the widows of Daguerre and Niepce.

One is astounded at the smallness of the sums accorded in exchange for one of the grandest of modern inventions, the importance of which was well understood, and from which there was no doubt great results would be obtained. It is true something was added to the value of these pensions by ornamenting them with the name of *National Reward.* But if the Government was thus careful of the public money, the nation at least was lavish in bestowing on Daguerre the marks of its great enthusiasm and admiration.[1]

The bill was passed with acclamation by the House and also by the House of Peers. Arago, as perpetual secretary of the Academy of Sciences, was charged to

[1] In our historical account we have rendered to Daguerre the glory which is due to him in the invention of photography. A distinguished writer, who has done us the honour to notice our work in the press, has accused us of partiality in saying that Nicéphore Niepce was the real discoverer of the art in question. Daguerre has been violently attacked by a son of Nicéphore, dispossessed of his titles by M. Victor Fouque, a critic, evidently sincere, but whose ignorance in the matter of chemical reagents has drawn him aside from the truth. We have endeavoured to judge impartially the old disputes which have been brought forward, and we make bold to say that we have retraced the facts in the light in which they ought to be studied. Is it necessary to add that in our work the researches of the illustrious inventor of the Daguerreotype have been estimated by the light of historical documents, that is to say without any preconceived ideas ?

communicate to that learned society the description of the Daguerreotype process. This was the name by which the marvellous discovery was to be henceforth known.

August 10, 1839, was the day fixed, and crowds of people curious to hear the secret thronged the approaches to the *Institut.* On this exceptional occasion the Academy of the Fine Arts had assembled at the Academy of Sciences. The seats reserved for the public were filled with those whom Paris counted her most eminent men. Every eye was fixed upon Daguerre, who, in his modesty, shunned the public gaze, and seemed to wish to divest himself of a triumph which the great Arago had taken under his special care.

It would not be necessary to know the Parisian public, so eminently impressionable and easily excited, to ask if the approaches to the *Institut* were crowded with people. All that Paris contained in the shape of artists, of young students, and inquisitive persons were to be found at the doors of the Mazarin Palace. Arago had spoken; his words were repeated by a hundred mouths, they circulated in the corridors, they burst forth on the quays, where comments flew about more or less explicit. 'It is the iodide of silver and mercury,' cried one person.' 'No,' said another, 'it is the bitumen of Judæa.'

'It is nitrate of silver, I tell you,' replied a third. Such exclamations as these were bandied about, but none had understood anything about Daguerre's secret.

Meanwhile the time passed, the papers appeared containing accounts of the solemn sitting of the Academy; they explained more clearly the Daguerréotype process. The opticians made experiments and exposed cameras and the necessary apparatus for taking Daguerreotypes in their shop-windows; these were at once pounced upon and disputed for by everybody who could afford to buy them, and all Paris had caught the Daguerreotype fever. The artists were seized with astonishment and admiration: Paul Delaroche sought out Daguerre, obtained a Daguerreotype plate from him and showed it everywhere, exclaiming—'Painting is dead from this day!'

The art of Raphael and Michael Angelo was not killed; on the contrary, it was to find new resources in the inspirations of a great inventor, and Science was about to give her hand to Art!

CHAPTER VI.

THE PROGRESS OF A NEW ART.

THE DAGUERREOTYPE PROCESS—ACCELERATING SUBSTANCES—IMPROVED LENSES—PORTRAITS—FIXING AGENTS—DISCOVERY OF PHOTOGRAPHY ON PAPER BY TALBOT—M. BLANQUART-EVRARD.

SOON after the memorable sitting of August 10, the processes of Daguerre were known to all Paris, all France, and one may even say, for so rapid was the success of the new art, to the entire civilised world.

All over the capital cameras were to be seen, perched on the balconies of houses, on the boulevards, before the monuments, everywhere. But these newly-improvised photographers obtained for the most part but poor results; the pictures they sought to fix in their cameras were generally indistinct, and showing perhaps but a few secondary objects of the coveted view. The method was simple and precise, but it required, nevertheless, a certain amount of practice in its delicate manipulations, and it required some time even for a good operator to make it profitable.

The photographic images obtained by the henceforth illustrious inventor of the Diorama were formed on the surface of a plate of silvered copper. The first operation was to iodise the silver. The silvered plate had to be perfectly polished and clean. First of all it had to be rubbed with a pad, or buff polisher (fig. 7), in order to give it the utmost possible brilliancy, and to remove from its surface the slightest trace of any foreign particles which might have got attached to it.

Fig. 7.

DAGUERREOTYPE POLISHER.

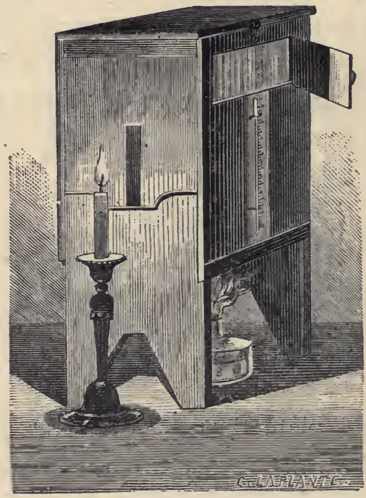
The silvered plate thus prepared was placed in the iodising box, in which it was supported by a frame over crystals of iodine.

The fumes of iodine act on the silver, combine with it, and form a yellow coating of iodide of silver.

The plate thus sensitised is then exposed in the camera, where it receives the image projected on to the prepared surface at the focus of the lens. The rays of light which form the image decompose the iodide of

silver just in proportion to their intensity, the parts exposed to the high lights of the picture undergoing the greatest change, while in the shadows the iodised surface remains unaltered. The most curious feature in this

Fig. 8.



MERCURIAL DEVELOPING BOX.

preliminary stage of the process is, that the plate when removed from the camera presents no visible signs of chemical change, although there is a latent image caught in the most delicate beauty of light and shadow upon its surface. In order to render this image visible it is neces-

sary to submit the plate to the operation of development, by placing it in a box above a bath of mercury gently heated to a temperature of about 50° Réaumur, ascertained by a thermometer. (See fig. 8.) The mercury emits fumes which, coming in contact with the prepared surface, have a liking for and condense upon the parts decomposed by the light, while the shadows protected by unaltered iodide of silver are shielded from the attack of this subtle developing agent. Thus gradually, as if by magic, the mysterious plate reproduces every detail of the scene before which the camera has been placed.

After the picture has been developed it becomes necessary to fix it, as, still susceptible to the influence of light, it would soon be blotted from the surface of the plate. In order then to remove the unaltered iodide of silver it is immersed in a solution of hyposulphite of soda,[1] which clears the shadows and leaves the lights and half-tones of the image intact.

The Daguerreotype image is thus fixed and is formed, as we have seen of a delicate coating of mercury; this metal, spread over the silvered surface, appears brilliant in the lights, whilst in the shadows it has not taken hold;

[1] The use of hyposulphite of soda as a photographic developing agent was made known in a paper by Sir John Herschel, published soon after the invention of the Daguerreotype process.—Ed.

the latter are represented by the polished surface of the metal plate, where the developer has laid it bare. But the picture thus obtained offered several grave drawbacks. Its mirror-like nature was one of the worst: in order to see the picture as fixed on the plate, it was necessary to hold it at a certain angle to the light, and it often appeared to have more of the properties of a mirror or stained tin plate than of an artistic drawing.

In Daguerre's time the exposure in the camera had to be prolonged for at least fifteen minutes; consequently to dream of taking portraits was out of the question; whilst if a landscape was attempted, the masses of verdure were represented by white silhouettes or monotonous blots.[1]

Besides these inconveniences, the Daguerreotype would not resist the slightest touch; a finger passed over it destroyed the whole picture; moreover, it did not long remain intact, a short time sufficed to deprive it of its sharpness.

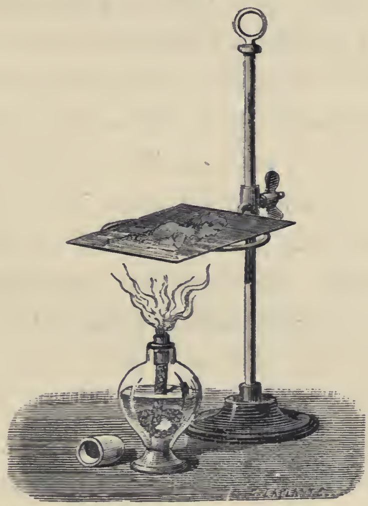
These difficulties were, however, overcome. A method of protecting the Daguerreotype picture by a process called gilding was discovered. This process consists in imparting a hardness to the coated surface by means

[1] The process was subsequently accelerated and rendered available for portraiture by Goddard's discovery of the rapid action of bromine.—Ed.

of a liquid containing gold in solution. Hyposulphite of gold and soda give excellent results.

This salt is dissolved in a large quantity of water, the Daguerreotype plate is immersed in this solution,and then gently heated over a spirit lamp, as shown in fig. 9.

Fig. 9.



GILDING THE DAGUERREOTYPE PLATE.

It is a fact in chemistry that one oxidable metal will displace another less easily oxidable ; for this reason, the mercury is dissolved and replaced by the gold on the silvered surface. As may be supposed, after this substi-

tution of gold for mercury, the picture has assumed a different aspect, but it has gained notably by the exchange ; it has acquired vigour, and become more pleasing in appearance, and, most important of all, is capable of resisting moderate rubbing. When the gilding is completed, the plate, after being well washed to remove the excess of salt is then dried, and finished.

As soon as Daguerre's invention was known, a great number of artists and men of science applied themselves to the practice and improvement of it. It will be readily understood that an essential improvement consisted in diminishing the time of exposure in the camera. To arrive at this result, it was above all necessary to alter the lens which produced the pictures. Daguerre had given rules which fixed the dimensions of the lens according to the different sizes of silvered plates used. But these observations of the clever experimentalist referred specially to the reproduction of general views of landscapes or objects at a distance. From all parts came anxious enquiries as to whether the Daguerreotype would not produce portraits ; and whether, as a writer of the time says, the prodigy accomplished in a story of Hoffmann was not soon to be realised, and, to quote the words of the author of the 'Contes fantas-

tiques,' 'the lover would present his mistress with a mirror in which she would see his image.'

To solve this problem it was indispensable that the focus of the lens should be shortened, and a greater quantity of light condensed on the plate in order to illuminate more vigorously, and thus more rapidly impress the sensitised surface. Charles Chevalier constructed a camera with two achromatised object-glasses, which gave a very sharp and brilliantly lighted image.[1] With this improvement the time of exposure was reduced to a few minutes.

'However,' says M. L. Figuier in his excellent essay on photography, 'this most important problem of lessening the exposure to the light was not completely solved till 1841, and then, thanks to a discovery of great value. Claudet, a French artist, who had bought of Daguerre the exclusive right to introduce the photographic processes in England, discovered the properties of accelerating substances.'

In photography the name accelerator is given to certain substances which, when applied to a plate previously iodised, increase in an extraordinary degree

[1] The double combination achromatic portrait lens was invented by Prof. Petzral of Vienna, and brought to a high degree of perfection by M. Voglander, whose lenses, some twenty years ago, were eagerly sought after, and are prized by photographers at the present day.—ED.

its sensitiveness to light. Alone, these substances are *non-photogenic*, that is to say they are not in themselves capable of producing a combination which would be chemically influenced by light, but if applied to a plate already iodised they give it the property of receiving the impress of an object in a few seconds.

The substances capable of thus stimulating the iodised silver are numerous. The first, introduced by Claudet, is chloride of iodine; but it yields considerably in sensibility to substances which were afterwards discovered. The fumes of bromine, bromide of iodine, bromide of lime, chloride of sulphur, bromoform, chloric acid, Hungarian liquid, Resier's liquid, and Thierry's liquid, are the quickest-acting accelerators: with chloric acid perfect pictures have been obtained in half a second.

By the discovery of these accelerating substances Daguerreotypes could now be taken of animate objects, and thus the long-desired portraits were at length attainable. Already in 1840, attempts had been made to obtain portraits with the Daguerreotype; but the long exposure necessarily rendered them fruitless. These attempts were made with the long-focus lens, which only admitted a light of feeble intensity into the camera; it was also necessary to place the person in full sun-light,

and prolong the exposure for a quarter of an hour As it is impossible to keep the eyes open so long a time to the effect of the solar rays, the sitter was obliged to close them. Many bold amateurs made martyrs of themselves in this way, but the result was not what their courage merited. In 1840 at Lusset's shop in the Place de la Bourse, might have been seen a row of sad Bélisaires, labelled 'photographic portraits'! [1]

The invention of short-focus object-glasses allowed—in the execution of portraits—the torment of the patient condemned to absolute immobility to be reduced to four or five minutes. But it was still necessary to sit in full sun-light. The model took a graceful attitude, resting one hand on the back of a chair, and looking as amiable as possible. But the sun fell full in his eyes! The operator gives the final warning to keep perfectly still! The seconds pass, succeed each other, and seem to expand into centuries; the sitter, in spite of all his efforts, is overpowered by the solar rays, the eyelids open and close, his face contracts, the immobility to which he is constrained becomes a torture. His features shrivel up, tears fall from his eyes, perspiration beads on his forehead, he pants for breath, his entire body shakes like that of an epileptic who wants to keep still, and the

[1] *L. Figuier, les Merveilles de la Science.*

Daguerreotype plate represents the image of a poor wretch undergoing all the tortures of the ordeal by fire. Shortly afterwards the discovery of the accelerating substances permitted Daguerreotype portraits to be taken with something of artistic feeling.

It is not our purpose to describe minutely the different Daguerreotype operations, and the various improvements effected; we shall content ourselves with noticing only the discoveries made by M. Fizeau, a French experimentalist. This clever operator discovered the means of fixing the Daguerreotype picture by covering it with a slight coating of gold. He arrived at this result, as we have seen, by pouring a solution of chloride of gold and hyposulphite of soda on to the plate and then gently heating it. With this discovery the complement of the processes used in photography was completed; the image of the camera fixed in a latent state on a sensitive substance was made to appear by developing agents, the time of exposure was lessened, and the picture could, by the action of chemical agents, be fixed, that is to say, rendered indelible.

Soon, other new discoveries were to transform, in every way, the art of Daguerre; but the illustrious inventor had not the consolation of knowing them. He died on July 10, 1851, foreseeing in his thoughts the new

horizons to the conquest of which the wondrous art he had created was rapidly marching.

Whilst Daguerre was carrying on his researches in France, in 1834 Mr. Talbot in England was also endeavouring to fix the image of the camera; but his aim was to fix it on paper.[1]

This modest and almost unknown inventor subjected a sheet of paper, which had been soaked in iodised silver, to the action of light in the camera; and he developed the picture, formed as in the Daguerreotype, in a latent state, with gallic acid. The employment of this substance was another great help to photography.

Talbot was in the midst of his researches when he heard of the publication of Daguerre's invention. He

[1] The English have claimed, but wrongfully, the merit of the invention of photography. Talbot's method was not practicable. If Talbot kept silence before Daguerre had published his discovery, it was because he was aware of the imperfections in his method. Before offering it to the public he desired to give it the certainty and facility of working which it arrived at in the hands of Blanquart-Evrard. The publication of the results obtained by Niepce and Daguerre established their titles as inventors of photography.

(While I am at one with the author in according to Daguerre the full credit of the beautiful invention which bears his name, yet the claims of Talbot can hardly with justice be relegated to a position inferior to that of the famous French inventor. Talbot in 1834, about five years before Daguerre's method was made known to the world, had solved for himself the problem of fixing the photographic image on paper. See Abridgment of Specifications, printed by order of the Commissioners of Patents in England, 1854.—Ed.)

sent the results of his experiments to France, to Biot, who brought them before the Academy of Sciences. But the Daguerreotype seemed to have the sole right to occupy the attention of Paris; people got tired of the numberless 'improvements' which were continually announced, for the most part merely the empty dreams of excited and inexperienced minds. Talbot's discovery had not the good fortune to attract the attention of the learned world. It was, however, estimated at its true value by a laborious spirit, Blanquart-Evrard, who cleverly profited by the facts made known by the experimentalist across the Channel, and who soon brought out an interesting memoir of photography on paper. Such a result was anxiously waited for; it was generally acknowledged that the mirror-like character of the Daguerreotype plate was incompatible with a really artistic picture; it was thought with reason that a proof on paper would be softer and would resemble a sepia drawing. Thus, as soon as Blanquart-Evrard of Lille published his method, his communications were received with expressions of joy by all photographic amateurs.

Blanquart-Evrard plunged his paper in a sensitising solution; when it was dry he fastened it between two pieces of glass and so exposed it in the camera. These new manipulations, it must be admitted, were almost

exactly similar to those employed by Talbot. The latter made use of iodised silver as a sensitising agent for procuring a positive proof on paper; he employed chloride of silver on the negative paper, and fixed the picture by means of gallic acid.[1] He had the first idea of making a negative picture to be used in the production of positive proofs; he must be considered as the inventor of proofs on paper, and his name ought to be inscribed in the annals of photography directly after those of Niepce and Daguerre.

Blanquart-Evrard, profiting by the interesting studies of Talbot, contributed to the improvement of the photographic art; he studied it wholly from an artistic point of view; he asked himself what were the rules which should be observed in order to obtain pictures possessing true harmony and worthy of being considered by a painter. He found out ingenious methods of giving force to the shadows, and of colouring the positive proof, and that by mixing certain chemical substances with the reagents already in use.

Blanquart at length was able to produce thirty or

[1] Amongst those who from its origin have contributed to popularise photography must be mentioned Bazard, who after patient researches succeeded in producing some, for his time, remarkable photographic proofs. They were exhibited to the students of the Sorbonne University of Paris by M. Despretz in 1846.

forty positives from a negative, whilst before, two or three were the utmost that had been obtained. It would be ungrateful to omit his name in the history of the photographic art.[1]

[1] See for further details on this subject the *Treatise on Photography on Paper*, by Blanquart-Evrard (of Lille), Paris, 1851.

A list of some of the processes which the publication of the discoveries of Daguerre & Talbot gave rise to is here given. Being quite out of date and superseded by processes subsequently discovered, a detailed description is unnecessary.

Amphitype.	A paper	process	proposed	by	Sir John	Herschel.
Anthotype		,,	,,	,,	,,	,,
Calotype		,,	invented and perfected by Mr. Talbot.			
Chromatype		,,	in which chromatic acid was used.			
Chrysotype		,,	discovered by Sir John Herschel.			
Cyanotype		,,	,,	,,	,,	,,
Energiatype		,,	,,	,,	Mr. Hunt.	

In another process for producing instantaneous views, galvanism was applied, the sensitised plate being under the influence of the fluid when exposed.

CHAPTER VII.

PHOTOGRAPHY.

SIR JOHN HERSCHEL—HYPOSULPHITE OF SODA—NIEPCE DE SAINT-VICTOR'S NEGATIVE ON GLASS—GUN COTTON AND COLLODION.

It is a remarkable fact in the history of great discoveries that the inventor himself is rarely able to give those finishing touches and improvements to the results of his genius which time and practice are sure to develop in them. The mind of the inventor, however ingenious he may be, creates only slowly and painfully. How often has it not been the case that after supplying some new materials to the edifice of science, the inventor seems to exhaust himself, and has had to give up his task to other hands! Many examples might be quoted in proof of this. Fulton, for instance, started to the conquest of the seas on a steamboat, rude and primitive enough: with this first effort his mind seemed to have exhausted itself; one might say that his faculties had not the gift of producing; they had invented this novelty, they were in-

capable of promoting its growth; it was reserved for others to give it the development of ripe age. Daguerre, after fifteen years of toil, gave the world the Daguerreotype plate, the first rudiment of photography; but here he stops, his genius can carry him no further.

But the seed sown on the field of discoveries is cultivated by other eminent minds, whose labours ensure the fruits of harvest. By the side of the inventor appear a crowd of those who, whilst capable of improving, are often incapable of inventing. The history of photography is a remarkable example of this. Fizeau, Chevalier, Talbot, Blanquart, have added their stones to the monument which was founded by Niepce and Daguerre; other great workers arrived from time to time to contribute their valuable aid to the work of building; the monument grows more magnificent and grand as the years pass on.

The new discovery had excited the admiration of all; the attention of the whole world was drawn to it. Here is the great Herschel, the illustrious English astronomer, taking photographic proofs; the attention of such a mind could not be directed to the Daguerreotype without exerting a salutary influence on it. He fixed the image on paper by the method of which he had read the description; the idea occurred to him of substituting

hyposulphite of soda for the agents until then employed. He succeeded beyond all expectation, and from that day the hyposulphite of soda has been counted amongst the most valuable substances of the photographic laboratory.

As soon as Blanquart-Evrard had published his process of photography on paper, it was immediately tried by everybody, and the use of the silvered plate abandoned. This last, it must be owned, certainly offered the advantage of being practical and of producing very clear, sharp pictures, with extreme fineness of execution in the details; it gave proofs of great delicacy of feature and matchless softness. But with paper, no more mirror-like reflection, no more of those metallic gleams which only permitted the picture to be seen after inclining it in every direction towards the light.

But everything has its good and its bad side; and the employment of paper, it must not be disguised, was accompanied with more than one inconvenience: the texture of the paper itself was not very smooth, its fibrous nature produced traces and unevennesses which prevented it from being impressed to an equal extent all over its surface. The paper was, moreover, too porous, it expanded and did not always uniformly absorb the liquids in which it was plunged; the photographic proof

obtained was no longer characterised by the same absolute sharpness of line, by the same harmonious degradation of light and shade. To alter this it was necessary to improve the photographic paper, to purify its pulp, to get rid of the grain and irregularities of its surface, and to make it homogeneous, smooth, and as clean as that of the Daguerreotype plate.

This problem was carefully studied and cleverly solved by an experimentalist, who has played a considerable part in the history of photography, Niepce de Saint-Victor, nephew of the inventor of the heliograph. He conceived the happy idea of having recourse to glass,[1] the surface of which is as smooth and level as that of metal, and of covering it with a slight coating of a viscous liquid, which possessed the property of solidifying and in which the impressionable substances could be dissolved.

To obtain his negative, Niepce de Saint-Victor coated a sheet of glass thinly with albumen (white of egg), which formed a homogeneous, smooth surface, extremely well adapted under good conditions to be used in the fixing of the image. To sensitise this coat of albumen, the in-

[1] Sir John Herschel used glass plates in photography as a support for sensitive films in 1839. It is a curious coincidence that Niepce de Saint-Victor, some years later, discovered, independently, the use of glass plates as supports for his albumen pictures.—Ed.

ventor impregnated it with iodide of silver, in the following manner: he first plunged it into a bath of iodide of potassium, and then into a solution of nitrate of silver; when dry the sensitised glass was ready to use for obtaining a negative picture at the focus of the camera. The negative, when fixed, gave paper positives, by means of the processes we have already described.

This discovery of Saint-Victor's was of immense importance to photography. But it was not the only help the photographic art was to receive from him, his various improvements indeed were of such real importance that we think it our duty to give a few details respecting the clever nephew of Nicéphore Niepce.

Like the discoverer of heliography, he was destined for the military career; leaving the military school at Saumur in 1827, he was made a lieutenant of the 1st Dragoons in 1842. It was at this time that he began to devote himself especially to the study of physics, which had always attracted his eminently scientific mind.

During his stay at Paris, Abel Niepce de Saint-Victor's taste for scientific studies received a fresh impulse. His relative's discovery had given an imperishable glory to the name, and, by a sort of family feeling, he seemed to be drawn into the pursuit of science. He commenced by studying physics and chemistry, and

turned his attention particularly to the investigation of the Daguerreotype phenomena. But a provincial town offered slender resources to a person in Niepce's position. Convinced that the capital would afford him greater facilities to carry on his researches, he applied to enter the Municipal Guard of Paris.

He was admitted with the grade of lieutenant in 1845. At the quarters of the Paris Municipal Guard in the Saint-Martin suburb, was a room belonging to the under officer of police, which was always empty. It was in this strangest of laboratories he installed himself. The camp bed formed his work table, and the shelves round the room held the apparatus, the reagents, and all the material necessary for his work. It was a curious spectacle, this laboratory in the midst of the barracks, this officer perseveringly prosecuting his scientific studies in spite of the continual calls of his profession. Our men of science are, usually, more at their ease ; they can pursue their studies under the most favourable conditions, everything which money can obtain to aid them is at their disposal ; they have vast well-stored laboratories calculated to facilitate their work ; after having had masters to teach them, they have pupils to whom they impart their learning. When success crowns their efforts they have the public, which applauds their discoveries, the

Academy which rewards them, and finally Fame which smiles upon them. Niepce de Saint-Victor was alone, as he was without a master so he was also without pupils; his budget consisted of his lieutenant's pay only, a police room served him for laboratory. During the day surrounded with all the paraphernalia of the savant, he gave himself up to his scientific studies, which were constantly being interrupted by the calls of his office; at night, with helmet on head and sword at side, he watched in silence over the tranquillity of the city streets, endeavouring to chase from his mind the thought of the work which was dearest to his heart.

The laboratory of this clever officer was burnt down on February 24, 1848, but afterwards M. Niepce de Saint-Victor was enabled to continue his interesting studies under excellent conditions, and other facts of the highest interest in photography were yet to be discovered by the relative of the illustrious Nicéphore Niepce.

In 1847, M. Chevreul laid before the Academy the new process of Niepce de Saint-Victor. But a few years later, in 1850, albumen was to be replaced by a new substance, which offered such advantages that it was not long in coming into general use to the exclusion of all others: we refer to collodion.

Gun-cotton was discovered in 1846 by Schoenbein,

who published it to the world of science principally as a fulminating substance. The new explosive caused universal astonishment. This cotton, apparently different in no way from ordinary cotton, which exploded like gunpowder on contact with fire, caused a veritable stupefaction ; it is obtained by submitting cellular substances such as cotton and paper to the action of a mixture of nitric and sulphuric acid. M. Schoenbein's method was to submit carded cotton to the action of a mixture of these acids. As often happens on the invention of new products, gun-cotton, which was to change the whole art of war, did not in reality bring it many new resources, but it was to prove of immense importance to photography.

The introduction of collodion in photography is due to M. Legray ;[1] a pamphlet published by this clever photographer near the end of 1856, makes mention of this substance, which Messrs. Bingham and Cundell, some months later, also attempted to substitute for albumen. Shortly after these experiments were made known, Scott Archer, in England, made collodion the basis of a nega-

[1] It is well known that M. Legray proposed the use of collodion in 1850, while Mr. Archer was prosecuting his independent researches in England, but it is to the latter we are indebted for the first practical details of a collodion process published in 1851.—Ed.

[See also Mr. Archer's letters to the *Athenæum*, in January 1852, and his *Manual of the Collodion Photographic Process*, published March 1852.]

tive process remarkable for its clearness and finish. It is this process, improved and perfected from time to time, which for more than twenty years has been the basis of nearly every photographic operation. Its principle is simple, thus: gun-cotton is dissolved in a mixture of alcohol and ether, and the collodion obtained, with the addition of iodides, and sometimes of soluble bromides, is poured on a glass plate. As soon as it has *set* through evaporation, it is plunged in a bath of nitrate of silver in order to impregnate it with iodide and bromide of silver. Charged with these insoluble compositions, and covered still with free nitrate of silver, the plate is exposed for a few seconds to the action of light in the camera. It is then removed to a dark room and submitted to the action of reducing agents to complete the decomposition which the light has commenced, and transform the latent image into a visible and negative picture. Sulphate of iron and pyrogallic acid are chiefly employed to produce this effect.

After *development* the picture or image is *fixed*, that is to say, deprived of the unaffected and still sensitive salts by means of hyposulphite of soda or cyanide of potassium. From a negative thus obtained any number of positive pictures on paper may be taken by

exposing paper sensitised with silver—placed under and in contact with the negative—to the action of light.

On the appearance of collodion the art of photography may be said to have been completed. We therefore close its history at that epoch.

PART II.

THE OPERATIONS AND PROCESSES OF PHOTOGRAPHY.

CHAPTER I.

THE STUDIO AND APPARATUS.

ARRANGEMENT OF A GOOD STUDIO—THE DARK ROOM—TERRACE—SITTING ROOM—THE INFLUENCE OF LIGHT—ARRANGEMENTS FOR LIGHTING THE OBJECT TO BE PHOTOGRAPHED—THE APPARATUS—LENSES AND CAMERAS.

THE photographic studio should consist of a room in which the camera and photographic accessories may be freely used, and of a dark room. It is necessary that

[In the Appendix the reader will find some formulæ in general use for obtaining negatives and printing positives on paper by the ordinary 'Wet Plate Process' as it is called, in contradistinction to the 'Dry Plate Process,' which is referred to farther on. By the Dry Process excellent results are to be obtained, but for general work the Wet Process is greatly to be preferred. But whichever process is employed, to get good results, it is a *sine qua non* that the chemicals used are of the best quality. The beginner will find it most economical to prepare all the mixtures himself, with the exception of the collodion. Before purchasing the more expensive photographic *materiel*, such as cameras or lenses, he would do well to get the advice of some friend acquainted with the subject.]

the latter should not be absolutely dark, as various manipulations have to be conducted in it; it may be lightened by means of a window with yellow glass or a yellow blind, or even by a lamp with a yellow shade (the yellow decomposes the light, allowing only the non-actinic or non-sensitive rays to pass through).

That part of the studio set apart for work not requiring protection from daylight needs no special description. It should have shelves arranged around its walls for holding bottles of chemicals, &c.; a work-table for cleaning glasses on, and a pair of scales are the principal necessaries.

The dark room should be arranged with the greatest care; in it the sensitive plates are prepared, and the various delicate processes which have to be guarded from daylight are performed. We have said that every ray of white light must be carefully excluded. It should be conveniently arranged, so that the operator has ready at hand all the things he requires when manipulating, which he has to do as quickly as possible. (Fig. 10.) A narrow table is fixed to the wall for supporting the sensitising baths, which have to be placed in a somewhat inclined position. There should be a row of shelves for holding the bottles of collodion and other chemicals. It is well to have a sink near the table with a tap above it

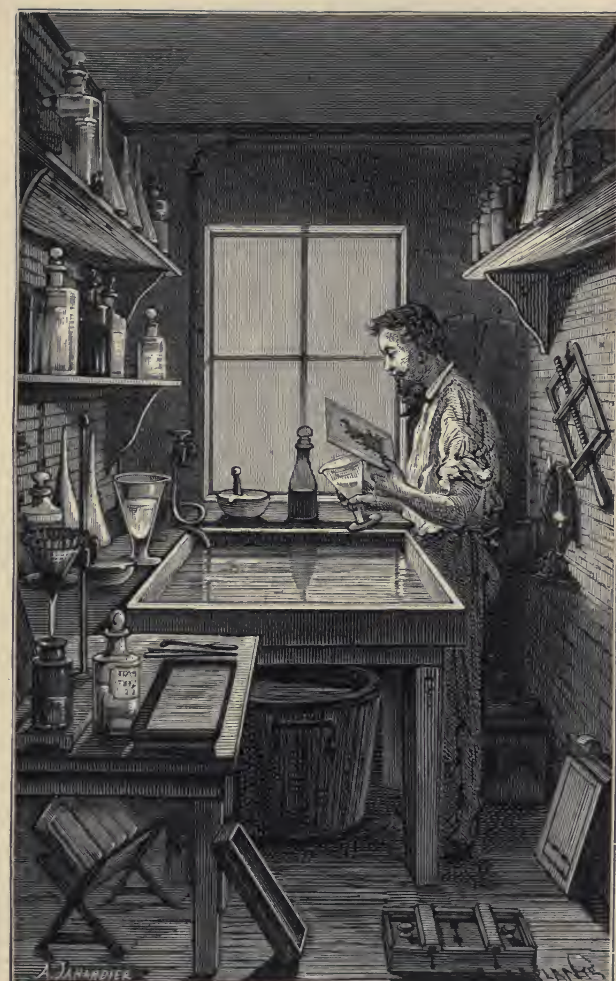


FIG. 10 [Page 90

THE DARK ROOM.

for washing the proofs; this tap may be advantageously fitted with a piece of indiarubber tubing having a rose at the end so that the water may be quickly and easily applied over a large surface.

A terrace well exposed to daylight is also necessary for exposing the printing frames containing the negatives to be reproduced on paper. If possible, there should be a second dark room placed near this terrace for the preparation of the photographic paper for taking positives.

The room in which the sitter is placed is the most important part of a good photographic establishment: it should be constructed in a position very accessible to the light, and lighted in a special manner. The mode of distributing the light in the posing room contributes to give the pictures produced that harmony which characterises really artistic photographs.

If the sitting room is only lightened by horizontal windows placed on one side, or if it receives light from all sides at once, the effect of the too strong or too feeble light thus obtained is equally prejudicial to obtaining good pictures.

The first condition in a good posing room is that it should face the north; if it is placed at the top of a house it should be glazed on one side and on the roof like

a conservatory—glass of a clear blue,[1] coloured with cobalt, should be chosen in preference to all other sorts; it has the property of sifting the light, allowing the chemical rays to pass, and producing a soft and harmonious effect. The side window and glass roof should be provided with large blue blinds capable of being easily drawn across any part where it may be necessary to intercept the light. To these preliminary precautions should be added others, which are particularly recommended by Mr. Liebert, an expert photographer.

'Cleanness of the glass,' says this clever experimentalist,[1] 'is likewise of great importance in regard to the rapidity of operations. The windows should be cleaned as often as necessary, so that the light may produce its maximum of rapidity. In order to soften and modify the effect of the intense glare on the eyes, the interior walls should be painted blue or light grey; green, yellow or red colours should be excluded from the room as giving unfavourable reflections.'

We subjoin some further hints from M. Liebert, which will be found useful in the employment of light

[1] Blue glass used to be greatly in vogue, but the pure homogeneous blue which admits only the most actenic rays of the solar spectrum is so difficult to obtain that its use has been for the most part abandoned in England. A skilful photographer, with the aid of a well-devised set of blinds and white glass, may manipulate the light so as to produce any effect he may desire.—ED.

[2] *La Photographie en Amérique.* Paris, 1864.

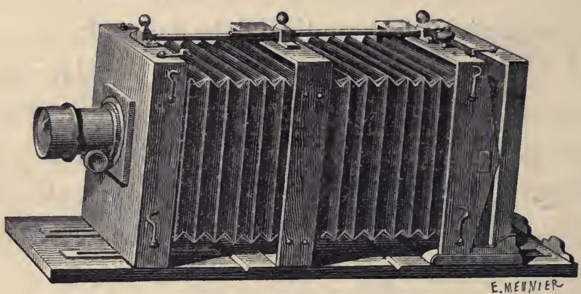
for photography. 'The chemical action of light varies considerably, according to the state of the atmosphere; on a bright, clear day it is more rapid than in dull, gloomy weather. The light, in order to act on the chemical substances employed to form the photographic picture, should be white. Gas-light, candle-light, even the light of the sun passed through a yellow glass, has hardly any effect on the nitrate of silver. The electric light, magnesium light, and daylight darken it.

'All colours are not reproduced with equal rapidity; thus black, red, yellow, and green take much longer to impress themselves than white, blue, lilac, and rose. The colours of the object to be photographed must therefore be taken into account in regulating the duration of exposure.'

For out-of-door views the most favourable conditions are those which place the different points of the landscape to be reproduced in a light of a nearly even intensity throughout, when the sun, approaching the zenith, projects the light from above, because the shadows are then least considerable. The light of sunrise and sunset, which produces such beautiful effects in Nature, is not so well adapted for photography, by reason of the feeble photogenic colours which are reflected in red or yellow, over the whole landscape. Nevertheless, certain pictorial

effects may be obtained by a photographer who is master of his art, when, soon after sunrise, or just before sunset, long transparent shadows veil the landscape. The time should therefore be chosen by the amateur when the sun, being at its highest lustre, is in the greatest possible harmony with the sky, in order that the objects in the

Fig. 11.



PHOTOGRAPHIC BELLOWS CAMERA.

view should produce an almost equal impression in the camera ; the effect of solarisation is thus avoided.

The apparatus with which photographs are taken, and which takes the place of the dark room, is called the *camera* ;[1] it consists of a plain or bellows box, at the back of which is a movable frame of ground glass.

[1] In the Appendix will be found an illustrated description of a 'rotating camera,' for taking panoramic views, &c.

The front is furnished with a brass tube (fig. 11), containing the lens.

The lens is the soul of photography. It should be constructed in the best manner possible by means of glasses thoroughly achromatised.

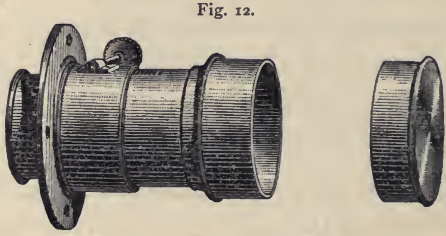
Everybody knows that the lens as it is used in the ordinary camera is a convergent glass, giving a reduced and an inverted image of exterior objects. This image is projected on to the ground focussing glass, which is placed at the back of the camera. It is hardly necessary to say that the size of the picture thus formed depends on the size of the lens and the distance from the object.

There are two sorts of lenses used in photography: the simple lens and the compound lens. The first is principally used for landscapes: it is constructed in such a manner as to give to all parts of the picture the same character of fineness, sharpness, and exactitude. The second is chiefly employed for the execution of portraits; the greater convexity of its glasses throws a very luminous image on the centre of the plate, though becoming less so as its edges are approached, thus enabling the operator to obtain a picture almost instantaneously.

The single lens consists of two glasses, the one con-

cave, which fits into the convexity of the other. This system of two glasses thus forms a single achromatic lens, the object of which is to destroy the coloured fringe which appears round the edges of non-achromatised glasses, and to render the foci of the different coloured rays of light coincident. The double or compound lens consists of the single achromatic lens with the addition of two other glasses, the first convergent, and the second

Fig. 12.



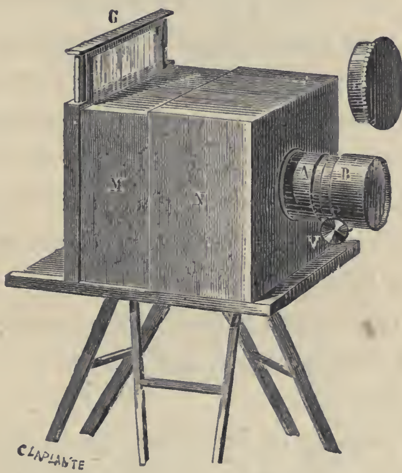
THE LENS, WITH ITS RACKWORK AND CAP.

concavo-convex. With the compound lens on a bright day, it is possible to obtain a photograph in one or two seconds; it is therefore employed, as we have already said, for taking portraits. Lenses are also made which can be used either for portrait or landscape work; in every case the lens-tube is furnished with a diaphragm,[1]

[1] In Fig. 17 the diaphragm is the piece of metal with circular opening in the centre in the slit of the lens tube; when pushed down into its place between the glasses the amount of light admitted into the camera is regulated by the size of its aperture.

the object of which is to confer sharpness on the image which would otherwise be indistinct; it is movable and can be used of various sizes, according to circumstances. The camera is also provided with a small

Fig. 13.



SIMPLE PHOTOGRAPHIC APPARATUS.

pinion which works in a line of teeth on the inner movable brass tube containing the lenses, by means of which the focus may be adjusted with the greatest nicety.

Fig. 12 represents the brass tube containing the lens; the milled head and rackwork are seen on the top

of the tube; and the remaining piece is the cap for excluding light.

The lens tube fixes on to the camera by means of a screw which works in a metal worm fixed to the camera. The body of the camera is formed of two distinct parts, sliding one into another in such a way that the operator can at will vary the distance which separates the lens from the focussing glass. This mobility of the focussing glass has been realised in a very simple practical manner, on the bellows principle, combined with a hinge, by means of which the focussing glass and the dark slide can be placed in all the positions necessary in the various conditions of taking a photographic picture.

Fig. 11 represents a bellows camera with hinge which is light and very portable, and can be shut up into a very small space.

In the majority of cases, very good results can be obtained with a camera formed as shown in fig. 13, without bellows. The two parts of this camera are made of wood, and represented by M and N. A and B are the tubes containing the lenses movable by means of the pinion V which turns the rackwork. The cap is shown a little above the lens tube. The frame con-

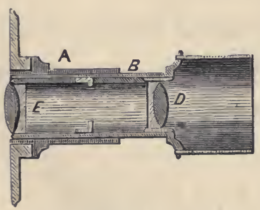
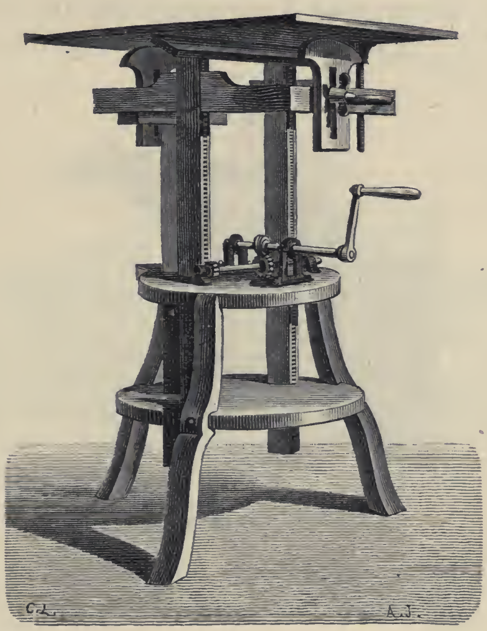


Fig. 14.

taining the focussing ground glass marked G works in a groove, into which also fits the dark slide (see fig. 14), containing the plate to be exposed. When the focus has

Fig. 15.



THE CAMERA STAND.

been obtained on the ground glass the latter is drawn out, and the dark slide containing the sensitised plate slipped into its place, so that when it is exposed to the light

exactly the same picture is thrown upon it as on the ground glass. A section of the lens arrangement used in this camera is shown in fig. 14. A is the fixed tube ; B the sliding tube which is enclosed by the former, and which allows the two systems of glasses at E and D to be moved.

The object of the lens, as we have explained, is to

Fig. 16.

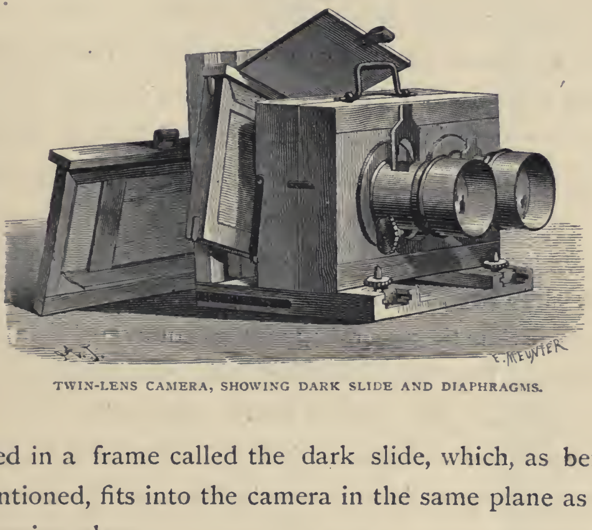
THE DARK SLIDE.

project a picture of exterior objects on to a screen placed at the back of the camera. This screen consists of a sheet of ground glass ; to examine the picture, which is reversed, the operator has to exclude as much light as possible from it, and for this purpose places a dark cloth over his head and shoulders ; but this is a manœuvre too well known to need description.

Fig. 15 represents a camera stand, by means of which the camera can be raised or lowered or fixed at any inclination desired. This is done by the aid of a complicated arrangement of screws as shown in our illustration.

To expose the sensitised plate in the camera, it is

Fig. 17.



TWIN-LENS CAMERA, SHOWING DARK SLIDE AND DIAPHRAGMS.

fixed in a frame called the dark slide, which, as before mentioned, fits into the camera in the same plane as the focussing glass.

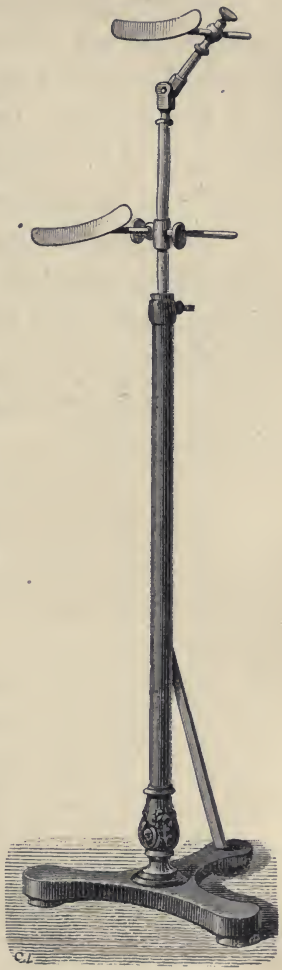
The dark slide is shown in fig. 16; it is made up of a frame forming a box. At the back of the frame is a door which opens and shuts. The sensitised plate on being removed from the bath in the dark room is placed

in the dark slide, film side inwards, and the door being shut, a spring, as shown in the illustration, presses against the uncoated surface of the glass, and holds it firmly in its place. On the front of the dark slide is another door, also made of wood, which slides in a groove, and when it is lifted up in the camera, until it can be turned over on hinges as shown in the drawing, the light of course falls on the sensitised surface of the plate as soon as the lens cap is removed. On the other hand, when it and the other door are both shut they keep the plate in perfect darkness, and thus permit the operator to carry it from the dark room to the camera and *vice versâ.*

Figure 17 represents the different positions of the dark slide before commencing operations. It shows at the same time the general appearance of a good twin lens camera. The photographer has examined on the ground glass the picture to be reproduced; he has obtained the necessary distinctness or sharpness by moving the brass tube containing the lens by means of the pinion; he has, in fact, focussed the picture, that is to say found, by trial, the optical focus point, the only point at which the picture presents perfect sharpness. He can now place the sensitised plate at this focus. He carries it in its dark slide, and after removing the ground glass,

carefully slides it into its place. He now pulls out the movable door, and the plate is then only protected from the light by the brass cap on the lens tube. He gives a last caution to the sitter to 'keep quite still,' removes the cap, and instantly the picture of the sitter imprints itself on the sensitive film. The cap is replaced, the sliding door again pushed down, and the plate in its slide removed to the dark room to be developed, intensified if necessary, and lastly fixed, as will be explained farther on.

Fig. 18.



THE HEAD-REST.

We shall have occasion to describe a great variety of other apparatus employed in photography in the course of our account of the different processes and methods which require their use. We shall, however, close this chapter with a short description of

the head-rest represented in fig. 18, an instrument which no portrait studio should be without. There are very few persons who can keep perfectly still, even for a few seconds. Their heads move without their being aware of it. They should, therefore, after taking graceful *pose* be supported by resting the head in the half-circle of the head-rest.

In adjusting the latter care should be taken that the position of the sitter is not altered, otherwise it will very often happen that a most objectionable stiffness is imparted to the patient, and a caricature rather than a portrait is the result.

CHAPTER II.

THE NEGATIVE.

MANIPULATION OF THE PHOTOGRAPH—CLEANING THE PLATE—COATING THE PLATE WITH COLLODION—PLACING IT IN THE SILVER BATH—EXPOSURE IN THE CAMERA—DEVELOPMENT, FIXING, AND VARNISHING.

HAVING thus got ready our studio, and the most necessary apparatus, we shall proceed to describe the delicate manipulations required to obtain a good photograph.

Cleaning the Plate.—After carefully selecting a number of glass plates of the required size, free from scratches, air-bubbles, or stains, and perfectly flat, the next process is to clean them. This operation does not consist, as might be supposed, in simply rubbing them with a cloth, but is much more minute and delicate. The plate is placed in a *plate-holder* (fig. 19), a wooden frame provided with a screw vice by means of which the glass can be held firmly without its being necessary to touch it with the fingers. The slightest contact with the hand, always a little greasy, is sufficient to prevent the perfect adhesion of the collodion. A plate-cleaning paste

is now made by mixing Tripoli powder and alcohol in a bottle. After shaking the bottle well, a little of the mixture is poured on to a piece of flannel, and the plate well rubbed with it. It is next dried with filtering paper, or, better still, with a paper of great delicacy called Japanese paper. In winter it is well to heat the plates slightly, to get rid of the humidity caused by the pre-

Fig. 19.

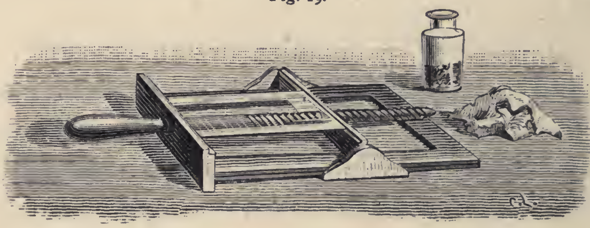


PLATE-HOLDER.

cipitation of moisture from the warmer atmosphere. We cannot insist too strongly on the extreme importance of perfectly clean plates ; if sufficient care is not taken in this respect, the success of the operation is at once compromised.

Collodion, its preparation.—Collodion is a thick transparent liquid, which possesses the property of solidifying when exposed to the air. It is made by dissolving gun-cotton in a mixture of alcohol and ether. Although it

is easy to procure good collodion ready made, we think it may be useful if we give the method of making it.[1]

Coating the plate with Collodion.—The collodion being thus obtained and ready to our hand in the dark room, we will proceed to describe the process of taking a photographic negative.

[1] Mix one part of dry pulverised nitrate of potash with three parts of concentrated sulphuric acid in a porcelain capsule, the nitrate of potash being put in first, and the sulphuric acid slowly added little by little. The mixture must be constantly stirred with a glass rod. It is then gently warmed to a heat of 60° *centésimaux*, ascertained by the mercurial thermometer. This may be done by adding water to the mixture, the quantity depending on the specific gravity of the acid. The cotton, which should be of good quality, well carded, very fine and clean, is now immersed in the mixture and well stirred and moved about with a glass spoon, so as to soak it well all through. It is left in contact with the sulphuric acid for the space of two hours, and is then well washed. It only remains to dry it and the gun-cotton is made.

To test the quality of the gun-cotton a little of it is ignited; it should burn very rapidly, without leaving any black residue.

The gun-cotton thus prepared is now dissolved in a mixture of alcohol and ether in the following proportions for plain negative collodion:—

Alcohol, sp. gr. ·725	2½ fluid ounces.
Sulphuric Ether, sp. gr. ·805 . . .	5 ,, ,,

Sixty grains of gun-cotton can be dissolved in the above quantity of alcohol and ether. The alcohol is first poured into a large-necked glass bottle with ground-glass stopper. The gun-cotton is next introduced, and the bottle well shaken in order to thoroughly soak it. Lastly the sulphuric ether is added, and the whole well shaken again until all the cotton is dissolved. A viscous syrupy liquid is thus obtained; it should be allowed to stand for forty-eight hours, and then decanted into a clean dry bottle, in which it can be kept until required to be sensitised.

To sensitise the collodion it is necessary to add certain chemical agents which, combined with the nitrate of silver, form a solution sensitive to light.

The plate, which has been cleaned with the greatest care, has now to be covered with a slight coating of sensitised collodion. This operation of pouring on the collodion is a somewhat delicate one, and requires a little skill and practice. The plate is held by one of the corners in a horizontal position between the thumb and forefinger; taking the collodion bottle in the other hand a small quantity, sufficient when spread out to cover the plate (fig. 20), is poured gently on to the middle. By

Various substances are employed for this purpose, but the iodides and bromides are chiefly used. The following alcoholic solution is recommended by Mr. A. Liebert for sensitising collodion:—

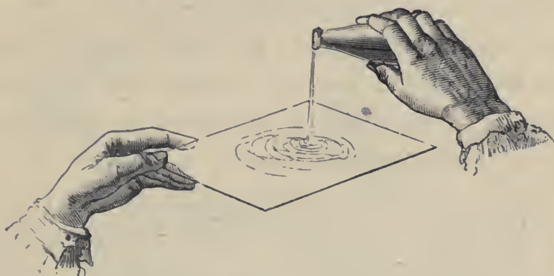
Iodide of Potassium	330	grains. (Eng.)
Bromide of Potassium	120	,,
Iodide of Ammonium	270	,,
Bromide of Ammonium	150	,,
Iodide of Cadmium	300	,,
Bromide of Cadmium	150	,,
Iodide of Zinc	180	,,
Alcohol of 40°	$1\frac{3}{4}$ Imp. Pint = 35 oz.	

The recipes for making sensitised collodion vary to an almost infinite extent, and we cannot pretend to give a list of formulæ, which would take us too far out of our way, and give the book too much the form of a treatise. We repeat that amateurs, and even photographers themselves, are in the habit of procuring their collodion ready sensitised of good makers. The methods we give are chiefly to enable the reader to understand the simple operations of photography.

[I need hardly add that it would be unwise for the amateur who has not made himself thoroughly acquainted with the chemistry of the operation to attempt to make his own collodion, as he would encounter a number of technical difficulties which can only be overcome by those who have made the manufacture of collodion their special study.—Ed.]

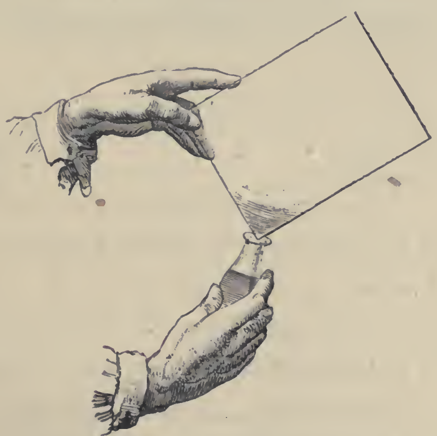
inclining the plate the liquid is made to flow first to the corner where the glass is held, avoiding contact with the

Fig. 20.



COATING THE PLATE. FIRST POSITION OF THE HANDS.

Fig. 21.



SECOND POSITION OF THE HANDS.

thumb, then to the top left-hand corner, then to the right

one, and lastly the surplus is poured back into the collodion bottle from the remaining corner (fig. 21).[1] Care must be taken that the collodion does not flow twice over the same spot, or, instead of being level, the surface will present unevennesses which will prove injurious to the development of the image. In order not to waste unnecessarily so expensive a substance as collodion, the beginner should get his hand in a little by practising with gum-water of a similar consistency. When the plate is coated and found to be free from streaks, points or blurs of any sort, and clear and transparent, it is allowed a few seconds to set by evaporation, it is then ready for immersion in the silver bath.

The sensitising silver bath for negatives may be made as follows:—

Recrystallised neutral Nitrate of Silver . .	350 grains.
Distilled Water	10 fluid ounces.
Glacial Acetic Acid	1 drop.
Iodide of Potassium	1 grain.

Dissolve and filter.

The bath for positives should be of 40 grains silver to the ounce of water.

Immersion in the sensitising bath.—The operation of plunging the plate into the silver bath must be performed

[1] Whilst the surplus liquid is running off into the bottle, and until it *sets*, which will be almost directly, the plate must be moved backwards and forwards, or ridges will form on the film.

rapidly without stopping, in order that the collodion film may be brought into contact with the liquid over its

Fig. 22.

SENSITISING TRAY.

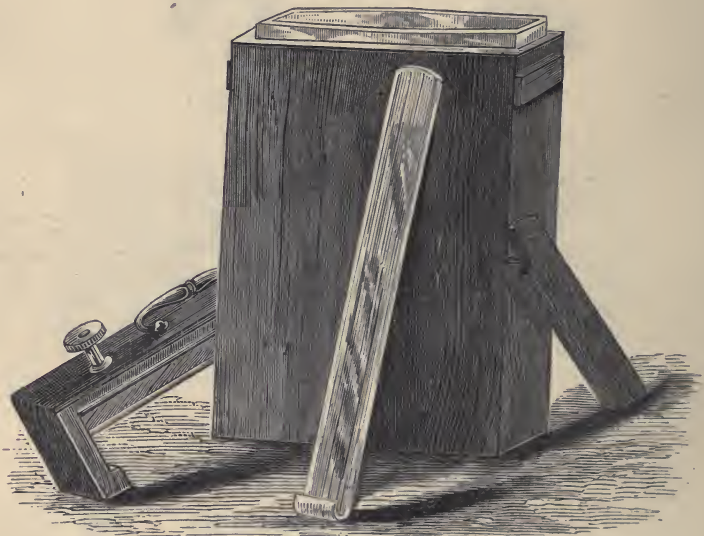
whole surface at the same moment. The dish containing the bath is tilted a little, so that the liquid collects at one end; the edge of the plate is then placed (see fig. 22) against the other end, and by means of a silver hook lowered into the liquid, the dish being brought back to the horizontal position at the same time; by this means the silver is made to flow evenly over the whole surface. The plate is allowed to

Fig. 23.

SILVER HOOK FOR RAISING AND LOWERING THE PLATE.

remain for a few seconds in the bath and then examined by raising one end with the hook; it should present a smooth, clear surface of an opaline tint; should this not be the case, and the plate have a greasy appearance,

Fig. 24.



GLASS BATH IN CASE WITH GLASS DIPPER.

it must be allowed to remain a little longer in the bath. Gently raising the plate in and out of the liquid accelerates the action of the silver.

Fig. 24 represents another and very convenient form of bath, usually made of glass; its interior sides are

concave, so that when the plate is slid in by means of a glass or other dipper, only its edges come in contact with the sides of the bath, the film being thus protected from scratches. Though this form of bath requires a larger quantity of the silver solution, it has nevertheless the advantage of being much more slowly exhausted, and can be protected from dust even when in use by means of a cap fitting on to the top.

The plate thus prepared is placed in the dark slide and *kept in a perpendicular position*, and is now ready for exposure in the camera.

Exposure in the camera.—It is impossible to give any definite rule as to the time the plate should be exposed in the camera ; the power of the lens, amount of light, quality of the collodion, colours of the object to be reproduced, &c., have all to be taken into consideration. Practice can alone guide the photographer.

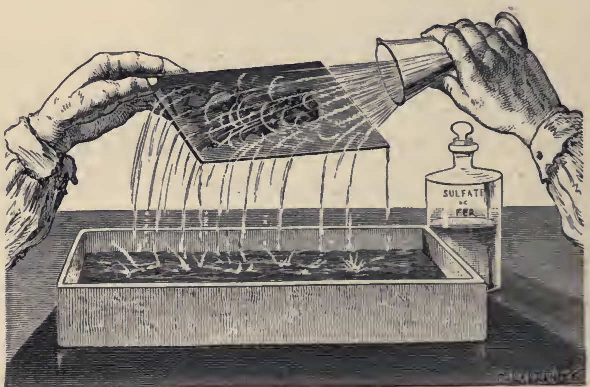
In the studio the time of exposure varies from three to thirty seconds. For landscapes the plate should be exposed in accordance with the nature of the collodion, the developer used, &c.

The amateur should accustom himself to count the seconds mentally, instead of always having to rely on a watch. As soon as the plate has been sufficiently exposed to the light, the sliding door is shut down and the

plate removed in its frame to the dark room, where the picture has next to be developed.

Development of the image.—After carefully excluding all white light from the room the plate is now removed from the dark slide and held by a corner between the thumb and forefinger in a horizontal position; the developing solution is then rapidly poured over its surface in such a way that the entire film is covered at once, as if it is arrested and allowed to remain for a second

Fig. 25.



WASHING THE DEVELOPED IMAGE.

longer in one place than another, it will certainly produce an indelible stain.[1] After the liquid has been made to

[1] The developer for collodion negatives is formed of a solution of proto-

flow in all directions it is returned to the glass and the operation repeated until the image is sufficiently developed. Before the application of the developer the plate presents an exactly similar appearance to what it did prior to exposure, and not the slightest trace of any picture is visible, but almost the instant the developing agent is applied a change takes place; first the lights appear, then the shadows, then the half-tones. But it is a negative, that is to say the whites of the model appear in black on the glass and *vice versâ*.

It is during this operation that one may easily determine if the time of exposure has been correctly calculated. If it has been too short, the whites appear instantly almost like ink blots, whilst in the shades and blacks the collodion remains opaline and unaltered. If, on the other hand, the exposure has been too long, the whole surface becomes covered with a greyish cloudiness on contact with the developer, and the picture is without

sulphate of iron in distilled water. A little acetic acid is usually added with a few dops of alcohol. The following makes a good developer:—

Distiiled Water	1 ounce.
Protosulphate of Iron	15 grains.
Acetic Acid	20 minims.
Alcohol	25 minims.

This solution can be made just before it is wanted for use. The strength and proportions of the ingredients in this solution may be greatly modified, but the alcohol should be added little by little until the developer flows freely and evenly over the plate.

sharpness. In either case it is necessary to recommence the operation.

When the exposure has been nicely timed, the picture appears gradually as if by enchantment, clear, pure, sharp; the details are admirably distinct; the lights are free from stains, and the blacks are represented by distinct tones varying according to the depths of the shadows.

A great number of substances are known at the present time which are capable of developing the picture; bisulphate of iron and ammonia, pyrogallic and formic acid, have been recommended by some operators.

It often happens that a negative picture is perfect as regards sharpness, but is wanting in intensity. In this case the vigour necessary to obtain a positive proof may be imparted to it by the process of intensifying.

Intensifying.—The developed plate is well washed, and is then subjected to the action of the developing solution, which must, however, contain a small quantity of the silver solution (one or two drops of the bath will do very well).[1] An intensifying solution may also be formed of water to which pyrogallic acid dissolved in alcohol and acetic acid has been added.

[1] Re-developing solution :—

Pyrogallic Acid	2 grains.
Citric Acid	3 grains.
Water	1 ounce.

After the operation of intensifying, as also after that of development, the plate must be well washed, to remove all traces of the iron and reagents which have been used. At least a quart of water should be poured on to the plate, care being taken that it does not get under the collodion film.

Fixing the negative.—To fix the negative it is necessary to deprive it of the iodide of silver, which, not having been affected by the light, would darken when exposed to it.

Hyposulphite of soda dissolves the unaltered iodide of silver.

The negative being developed and washed is now plunged into a solution of hyposulphite of soda in water contained in a porcelain dish (8 oz. of hypo. to 40 oz. of water), and allowed to remain there for a minute or two until the yellow coating of iodide of silver is entirely dissolved. The plate should be raised out of the bath with a hook and carefully examined and returned to the bath if the slightest trace of the silver is visible. When perfectly clear it must be well washed as before to get rid of the hyposulphite adhering to its surface.

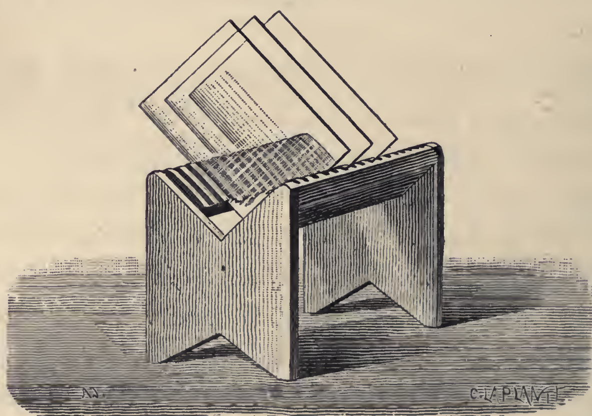
Cyanide of potassium (a most deadly poison) is also used for fixing purposes; it is employed in the same way as the developing solution, and is cleaner and gives per-

haps a more vigorous, sharp picture, with finer detail than the hypo. (8 or 10 grains of cyanide of potassium to 1 oz. of water).

The negative is now finished and may be exposed to light. But the collodion film is liable to be scratched on the least contact with a hard surface or with the finger nails; it is therefore necessary to protect it by covering it with a coat of varnish.

A special varnish is sold for this purpose, which is

Fig. 26.



RACK FOR DRYING PLATES.

transparent, soon dries, and becomes very hard. The plate should be gently heated over a spirit lamp or

before a fire (the safer plan), until it can be just borne on the back of the hand, the varnish is then poured on exactly as if coating a plate with collodion, and the excess returned to the bottle ; the plate is then again gently heated until quite dry, when the picture will be protected from the effect of any accidental abrasion.

A less perfect temporary protection is afforded by a solution of gum arabic (10 parts of gum to about 100 of water).

Fig. 27 represents a useful form of box for containing

Fig. 27.

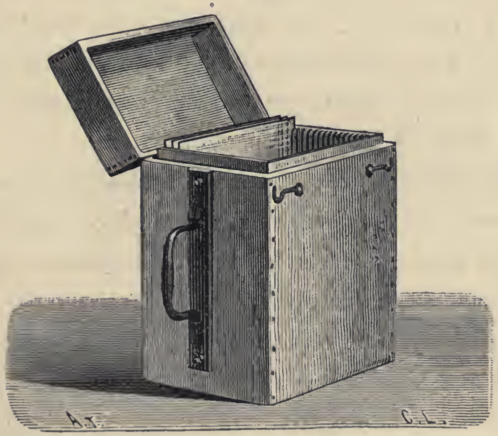


PLATE BOX.

glass negatives, which are held in grooves, and kept free from contact with each other.

The image of the camera which has thus been developed, fixed, and varnished, adheres to the glass, but it presents a negative picture of which, viewed by transmitted light, the blacks are the whites of the model.

We shall now see how the positive proof on paper is obtained ; but we think it would be well first to point out a few characteristics by which a good negative may be known. It is not always an easy matter to determine ; to an unpractised eye a plate might appear excellent, in which a skilful operator would perceive faults which would prevent its yielding a good positive. In a good negative viewed by transmitted light the shadows, draperies, and stuffs should be highly transparent. The whites and high lights on the contrary should appear almost perfectly black or opaque.

It should also present a marked shading between the half-tones and in general a well-defined gradation of light and shade. If during this examination pin-holes, stains or streaks are apparent, or if the most minute details and smallest objects are not clearly and sharply defined, another photograph should be taken. The imperfections of the negative are exaggerated in the print, and all one's toil and trouble thrown away.

It often happens that the operator searches in vain for the cause of imperfections in a negative, in taking

which he seems to have used every precaution ; it is impossible to lay down fixed rules to meet every failure. But the beginner should bear in mind that unforeseen accidents are rocks ahead, which he will frequently meet with in his labours.

The photographer, like the chemist, should be patient, persevering, and endowed with tenacity ; difficulties, far from discouraging, should serve to stimulate him ; he should not be disheartened at repeated failure, but learn to lean more and more on that great teacher, experience.

CHAPTER III.

THE POSITIVE ON PAPER.

PRINTING ON PAPER—OF THE NATURE AND QUALITIES OF PHOTOGRAPHIC PAPERS—VIGNETTES—EXPOSURE TO THE LIGHT—TONING, FIXING, PRESSING THE PROOFS.

Preparation of the sensitised paper.—Photographic paper can be bought partially prepared ; it is formed of close-grained pulp and presents a surface smooth and glossy.

It is easily prepared. A paper of good quality is chosen, its surface must be free from stains. It is necessary that the sizing of the paper should be very carefully done. The different processes of sizing give different colours in the positive. If albumen is used, the proof will be slightly red ; whilst if gelatine is used, it will be of an orange-red colour.[1]

The paper being chosen, the albumenised being most generally used, it is next plunged into a solution

[1] The colour, as will be seen, depends greatly on the subsequent toning with gold.—ED.

of salt or chloride of sodium (450 grs. to 2 pints of water), in which it is allowed to remain for a few minutes, and is then dried in the air. To sensitise the paper thus prepared, it is only necessary to float the sized surface on a bath of nitrate of silver (60 grains of silver to 1 ounce of distilled water) contained in a porcelain dish. When the surface is well saturated, it is allowed to dry in the dark.

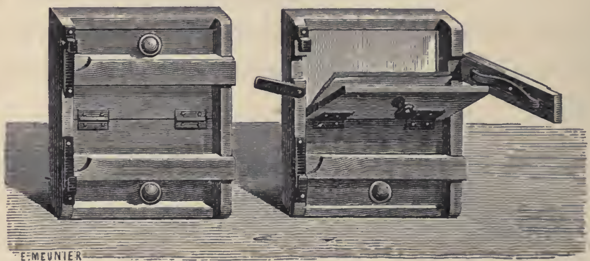
The albumenised paper of commerce contains chloride of sodium or ammonium, and to sensitise it it is only necessary to float it on the silver bath ; but it ought not to be sensitised long before it is intended for use, as it soon turns yellow even when kept in the dark.

It may be well to mention here that the silver bath for the collodion plate must be kept separate, and never used for any other purpose. The slightest admixture of any foreign substance would at once render it useless. It should be filtered when necessary.

The bath for sensitising the paper can be used over and over again, nitrate of silver being added from time to time to strengthen it. The solution will become discoloured after a few sheets have been floated on it, but this colouring matter can be readily precipitated by means of a little Kaolin powder, when the cleared portion of the liquid may be gently decanted into another bottle.

Printing from the negative.—Special frames called printing frames of various sizes are used in this operation. The printing frame, oblong in form, is made of wood to

Fig. 28.



THE PRINTING FRAME.

hold the glass plate, in the same way as an ordinary picture frame, but the back is provided with a double door hinged across the centre, which can be fastened down by means of transverse bars of wood (see fig. 28). The printing frame is provided with a sheet of plate glass, which must be perfectly clean on both sides; the negative is then laid down with its uncoated side next the plate glass. The sensitised surface of the paper is now placed on the collodion film and the whole securely fastened, and held in close contact by means of the wooden back, which is lined with black felt. This operation having been conducted in the dark room, the plate is now ready for exposure to sun-light.

If the negative is vigorous and intense, it may be exposed to the direct rays of the sun, if weak and not sufficiently intense, it should be placed in the shade. During the process of printing, it is necessary to examine the proof from time to time until the requisite depth of colour is attained. This may be done, of course in the shade, by removing one of the transverse bars and turning back the top half of the hinged back; the part of the paper thus set free can then be seen without fear of shifting, which would of course spoil the picture. If not sufficiently printed, the paper is again fastened down, and the exposure continued (fig. 29 represents the printing frame exposed to the sun).

When vignette pictures are required, a vignette glass is used.[1] This is a glass colourless in the centre, but towards the sides tinted yellow, the colour gradually increasing in depth. A vignette glass may be made by pasting layers of paper over a glass plate in such a way that whilst the desired space in the middle

[1] The simplest method of vignetting is to cut an oval aperture in a sheet of opaque cardboard, about a third smaller than the space to be taken up by the finished picture. The aperture must then be covered by a thin sheet of tissue paper. This vignetting screen is fixed outside the plate-glass of the frame, care being taken to place the aperture directly above the part to be vignetted. When the card is in position the frame must then be placed so that the direct rays of the sun passing through the tissue paper will become diffused, and print a delicately shaded vignette of the required dimensions.—ED.

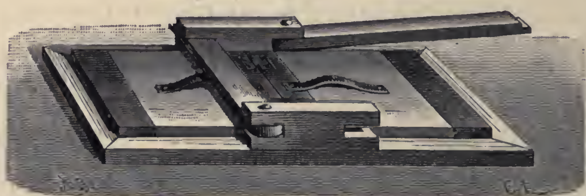
of the glass is left open, it gradually becomes opaque towards the edges, the thickest layer of paper being

Fig. 29.

PRINTING FRAMES EXPOSED TO THE LIGHT.

farthest from the transparent centre. The action of the vignette glass will be easily understood. It is placed

Fig. 30.



SIMPLE PRINTING FRAME.

over the negative, and thus the action of the light is confined to the transparency of the centre, acting only

slightly through the thinner paper, or fainter yellow of the vignette glass; the rest of the proof being perfectly protected, a white background is thus obtained.

As soon as the printing has been sufficiently prolonged (the time varies according to the intensity of the light), and shows the desired depth of colour, it is removed from the frame in the dark room, and subjected to the operation of toning and fixing.

An albumenised print on being taken from the frame should be of a very dark brown tone, or slightly bronzed in the shadows; it will lose much of its intensity when fixed; the operator therefore always prints his pictures a deeper colour than he desires the finished proof.

Toning.—If the excess of silver is at once removed from the print by means of hyposulphite of soda, the result is a picture deficient in depth, and of a disagreeable pale red colour. The print, after being allowed to soak in a basin of cold water, is therefore first plunged in a toning solution formed of 5 or 6 grains of chloride of gold to 2 pints of water, a few grains of acetate of soda,[1] or about 100 grains or half a tea-spoonful of carbonate of soda being added; the mixture must be allowed to rest

[1] Acetate of Soda	1 drachm.
Chloride of Gold	3 grains.
Water	20 ounces.

for about fifteen minutes before it is used. Whilst in this solution the prints will gradually become of a vigorous violet or black tone according to the time they are allowed to remain in it; which is usually from 10 to 15 minutes, until indeed they present the deep sepia colour which constitutes the true beauty of the photograph.[1]

Fixing.—The print being properly toned and subsequently well washed is then ready for fixing. The process of fixing the positive is very similar to that of the negative. Hyposulphite of soda neutralised by the addition of one per cent. of chalk gives very good results (6 oz. of hypo. to 2 pints of water). An immersion of fifteen minutes in this solution will be sufficient to remove the unaltered silver, and after being again well soaked in water three or four times changed, and dried, the proof is finished.

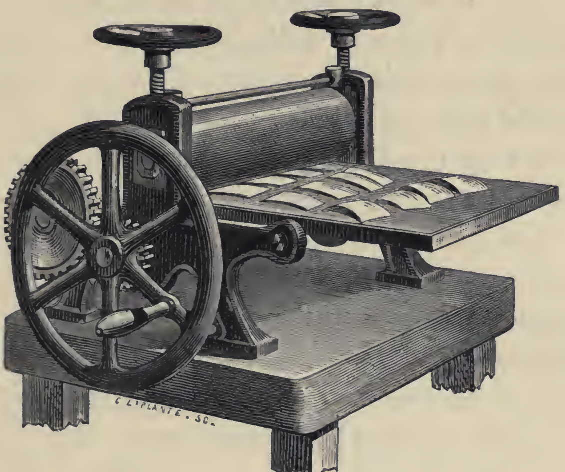
To ascertain if the print is sufficiently washed, a few drops of the last bath it is soaked in are allowed to drip from it into a glass, a small quantity of bichloride of mercury (corrosive sublimate) in solution is then added.

[1] There are various solutions used for toning, but that we have given is perhaps one of the best. If acetate of soda is used the solution must stand for ten or twelve hours before any prints are toned in it; but it will keep good for months, a few grains of gold being added from time to time to keep up its strength. The carbonate of soda solution can be used almost as soon as made, but will not keep long.

If the print has been sufficiently washed there will be no precipitate, if on the contrary there is a precipitate, then the washing must be continued until such reaction does not manifest itself.

Mounting and Rolling.—The proof after being thus

Fig. 31.



THE ROLLING PRESS.

thoroughly washed is hung up to dry by one of its corners to a cord stretched across the studio, and when dry placed in a press or under a heavy weight to prevent its creasing. When cut to the right size it only remains to mount the proof on cardboard and to roll it.

The mounting is best effected with a starch paste prepared with boiling water. The rolling is done by means of a special press (see fig. 31) formed of a smooth metal plate which can be moved horizontally backwards and forwards under a roller by means of a toothed wheel and pinion. The mounted proofs after being dried in a warm room are placed on the plate (as shown in the illustration), and then subjected to great pressure by being passed under the roller. This gives them a beautiful gloss and finish.

Such are the different operations which have to be performed to obtain a positive photographic proof by the most generally practised method from a collodion negative. We will only add that, however minute the descriptions, practice is the operator's best guide. He should endeavour to master the theory of the different processes, but must not forget that a long apprenticeship is necessary, and that patience and unwearying application are indispensable qualities in the photographer.

To anyone ever so little acquainted with chemical manipulations the different operations which we have just described are not very difficult; but what protracted efforts, what a delicate, patient, minute feeling of the way it required on the part of the inventors of the wonderful art! What an abyss of labour and research separate

the actual methods of which we have just given an outline, from the first experiments of Niepce and Daguerre!

After these grand inventors, what numbers of ingenious and laborious minds have long worked at the problems of photography, each adding some new elements to the results obtained before them!

May we not say that it is the character of the works of modern science to be in a great measure the result of multiplied efforts, isolated from each other, but simultaneous and all tending to the same end? Most of the discoveries of our century are a striking proof of this; and photography is certainly one of those which has demanded the greatest concourse of intelligent workers, pursuing with perseverance researches always difficult and often unprofitable.

CHAPTER IV.

THEORY AND PRACTICE.

EXPLANATION OF PHOTOGRAPHIC OPERATIONS—NECESSITY OF LONG PRACTICE—MODIFICATIONS IN PROCESSES REQUIRED BY DIFFERENT SORTS OF PHOTOGRAPHY—PHOTOGRAPHY AND TRAVEL—LANDSCAPES—SKIES—PORTRAITS—INSTANTANEOUS PHOTOGRAPHY.

WE have described the different operations which the production of a photographic proof necessitates; we do not think it is necessary to expatiate on the theory of the reactions on which is based the series of photographic manipulations. In the historical part we have already referred to the scientific groundwork of photography; a few new details may, however, help to better fix the reader's ideas.

It is not known by what wonderful influence light affects certain chemical agents; science is almost always powerless to explain causes; it discovers effects, it brings them under control and profits by their application.

Light acts on the nitrates of silver.[1] Why? No

[1] Light, as we have seen, acts also on a great number of other substances. Here is a curious experiment which plainly shows its action. It was made by Messrs. Garnier and Salmon, and published in the Bulletin of the French

one knows and perhaps no one ever will know, but the fact is manifest, and this action is the fundamental basis of photography.

The glass plate is covered with collodion, a viscous substance which solidifies on contact with air, and is well adapted as a base for the silver solution. The collodion contains iodide of potassium ; when the coated plate is plunged into the nitrate of silver bath, the iodide of potassium is transformed into iodide of silver.

The plate thus sensitised is exposed in the camera. The light acts on the iodide of silver in the light parts of the picture, leaving the shadows intact. On being taken from the camera the picture is developed by means of a solution of proto-sulphate of iron to which acetic acid has been added. The sub-chloride of silver formed by the action of light being completely reduced, the metallic silver is deposited and soon becomes a very pronounced and vigorous dark shade. If not sufficiently vigorous at first it is intensified by the addition of a little nitrate of silver solution to the redeveloper, which is poured over the plate, and a fresh quantity of metal deposits on the parts already reduced, strengthening the picture and

Photographic Society. Sulphur undergoes a singular alteration when submitted to the action of light. If, after being thus exposed, it is brought into contact with fumes of mercury, the fumes only attack those parts which have been acted upon by the light, turning them a brown-yellow colour.

giving it greater intensity. The *fixing* is done by means of hyposulphite of soda or cyanide of potassium ; these salts dissolve the iodide of silver which has not been affected by the light.

It will be seen that these theoretical outlines are very simple ; it is not necessary to be versed in the study of chemistry to understand them. But the theory of an art and the being able to practise it are very different things. The latter is only to be acquired by long and patient manipulations, by numerous and often-repeated experiments. It is the more difficult to be taught in a work such as the present, inasmuch as it varies according to the result desired.

All that we have so far said on photographic operations refers principally to experiments made in a studio where the light can be controlled at will, and where a dark room and all the necessary apparatus are at hand. But we have not entered into the particular details of the precautions which are necessary in taking portraits from nature ; we have passed in silence the accidental causes which alter a negative—in one word the minutiæ which practice alone can teach. Just as it is impossible to become a chemist without studying in a laboratory, so is it folly to hope to become a photographer except with the collodion bottle in the hand and the camera before the eyes.

Nevertheless, as the inexperienced beginner, learning for himself, must have recourse to the advice which books offer him, and as at present we have not sufficiently referred to the different applications of photography, we shall give some information respecting the various modes of operation which are necessary for photography in travel, instantaneous photography, and some special branches of the art.

Outdoor Photography.—The travelling apparatus differs from that of the studio ; it is much lighter and more portable. The camera is much smaller and is furnished with a bellows which can be extended and contracted at the will of the operator. It is supported on a tripod stand, the feet of which fold up, or slide in grooves. It is furnished with straps which secure almost all the apparatus, including a tent to serve as a dark room. The whole can be easily adapted to the shoulders of the tourist, so that he may thus carry his complete material without fatigue. (See fig. 32.)

The lens[1] screws on to the camera, so that it may be carried separate. This lens is simple, that is to say it consists of but one achromatic lens, sufficient for photo-

[1] In England view lenses are manufactured in great variety, double and single wide angled, with short focus, and others with a more contracted field and longer focus. Many lenses, such as those of Ross and Dallmeyer, are deservedly famed all over the world.—ED.

graphs of views and monuments. We specially recommend the orthoscopic lens invented at Vienna. It con-

Fig. 32.

PORTABLE PHOTOGRAPHIC APPARATUS.

sists of a double combination of achromatic glasses, the position of the diaphragms at the back of the lens tube

permitting the utilisation of almost all the light entering through the glasses. Another great advantage it offers is that it gives more nearly the true perspective and straighter lines in monuments than other lenses.

As before mentioned, the photographic tourist must be provided with a dark tent, which can be procured very compact and which need only be large enough to take in the upper part of the body. It can be readily set up, and contains the silver bath, a rack for the various bottles, and a reservoir on the top to hold a supply of water for washing the plates, a sink for getting rid of waste; in fact everything which the artist requires.

The photographic tourist, if he is a good operator, will readily be able to produce views of monuments and buildings in general; but if he attacks nature, if he attempts studies of skies, or tries to fix on his collodion the effects of the shadows which adorn the landscape, he will encounter difficulties which will prove insurmountable, unless his perseverance is equal to his ambition.

'One of the greatest difficulties of the landscape photographer,' says the talented artist, M. A. Liebert, to whom we have already referred, 'is the production of skies with natural clouds, because the light, from its great strength, destroys all the cloud shadows by solarisa-

tion; the result is skies whose uniform whiteness produces a monotony which deprives the landscape of its aerial or natural perspective; all the delicate tints produced by distance and the reflections of the clouds disappear; the image thus loses a great part of its artistic value.

'Various methods may be employed for obtaining clouds in the sky of a landscape. The first consists in operating instantaneously and then reproducing the natural sky, which is thus in keeping with the rest of the picture; but with a little practice in development of the image clouds may be obtained. The best way to manage the clouds during the development of a picture which has been shortly exposed consists in covering the glass with a very weak neutral reagent, until the clouds are developed; the rest of the picture is then subjected to the ordinary development, care being taken to confine the solution as much as possible to the landscape itself.

'When a picture is to be printed with the sky of another negative care must be taken to select a sky appropriate to the subject in order to secure harmony. In such a case it is necessary to bear in mind the effects of light, so that the clouds and the picture may be alike as regards the light. The horizon lines should keep their

character, the sky which is less distinct in the distance gradually becomes more definite in the higher parts of the picture. These delicate operations require great care and taste, and, above all, artistic feeling.'

The same artist gives excellent advice to the landscape photographer, and with good right claims the title of work of art for a picture obtained under good conditions.

'To give the true artistic effect of a landscape, it is important to discover that view of it which presents the greatest harmony in its *tout-ensemble*, and to choose the time of day when this view is in the best light for reproducing its objects in their true significance and character, and when the effects of light and shade are in keeping with form and distance.

'Thus it will be seen that great taste and judgment are required to produce a picture really worthy the name of a photograph, and this applies equally to portrait as to landscape work. Unfortunately for the beautiful art it is often enough disgraced by distorted effects in black and white, which have as little right to the title of photographs as their producers to that of photographers.'

By repeated improvements in the lens and the various solutions employed, the time of exposure has been reduced to the fraction of a second, so that it is possible to obtain photographs of a horse in full gallop, a pass-

ing regiment, a wave just breaking, or a flying cloud. The collodion for instantaneous pictures should be very fluid. This collodion is sensitised with iodide of lithium and bromide of lithium. The silver bath of 8 parts of silver to 100 of water is saturated with iodide of silver, a few drops of nitric acid are added, and the coated plate is allowed to remain in this bath for five minutes. By this means the maximum of sensibility is obtained. The developing solution is made of sulphate of iron to which acetate of lead, formic acid, and nitric ether have been added.[1]

[1] It is impossible in a work like this to give a detailed account of the various instantaneous photographic processes. They all present difficulties of manipulation which can only be overcome by the experienced operator. —Ed.

CHAPTER V.

RETOUCHING.

ACCIDENTS WITH NEGATIVES AND PROOFS—METHOD OF REMEDYING THE SAME—RETOUCHING THE NEGATIVE—IMPERFECTIONS IN THE POSITIVE—RETOUCHING PHOTOGRAPHIC PROOFS WITH INDIAN INK —COLOURING PHOTOGRAPHS—PHOTOGRAPHIC CARICATURES.

IN spite of every precaution on the part of the operator, the photographic negative, as well as the positive proof, are often imperfect. Unforeseen and often inexplicable accidents frequently mar work which has cost much time and trouble.

A few seconds' over-exposure, the development pushed a little too far, the slightest impurity finding its way into any of the reagents employed, a ray of light—any one of these is sufficient to spoil the picture, cover it with a cloudy fogginess, puncture it with pin-holes, or mark it with lines which destroy the purity of the drawing.

Pin-holes and small spots on the negative often arise from badly cleaned glasses. If there happen to be a few grains of Tripoli powder or a few dust spots on the plate, the collodion coating will make them apparent however

minute ; they will prevent the developer acting on the spot they cover, and will form very visible marks in the proof.

Transparent pin-holes in a negative can be touched out with Indian ink slightly gummed.

Imperfections in the positive proof can be corrected by careful touching with Indian ink to which a little gum and carmine have been added.

The photographic proof can be used by the artist as a sketch on which he can work with his pencil or brush, and is thus transformed into a miniature or crayon.

Protests against the use of pencil or brush on the photographic proof have not been wanting ; in the Third Part of this work we shall consider the system of retouching from the artistic point of view ; for the present we shall only regard it in a purely practical light.

The retouching a positive proof with Indian ink should be done before the operation of rolling ; it is very rare, we repeat, that this retouching is not necessary, especially in portraits. The sitter often moves his eyes, which prevents their appearing sufficiently distinct and sharp in the photograph ; the draperies do not always present enough vigour in shade. A few delicate touches with a brush easily repair these and similar imperfections. It is often necessary to retouch the whites of a picture

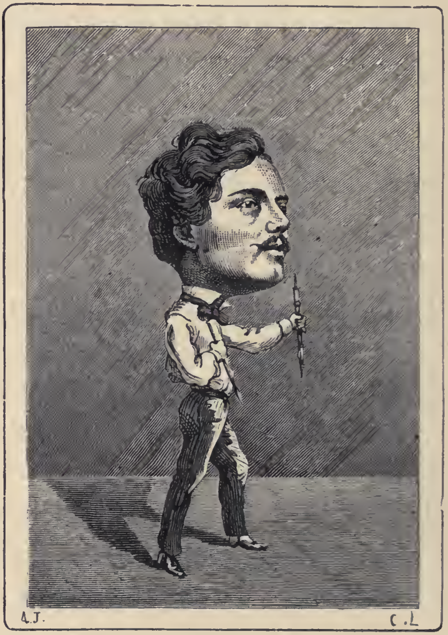
which appear too much like pure blots without shade or half-tones. A man's shirt nearly always prints like a white triangle, without folds and without trace of studs, and thus produces a lamentable result in the midst of a picture which may be otherwise perfect. A touch of Indian ink or sepia with a fine brush will soon remedy such defects.

Photographs intended to be coloured with crayon or water colours should be printed on plain salted paper. These coloured proofs rarely look well ; and oil-painting on the positive also gives but a poor result. In the latter case the proof is printed on canvas. We shall, however, see that the photographic art is capable of rendering great service to painters of the greatest talent. If *painted* photographs are held in but little esteem it is because they mostly owe their origin to *colourers* rather than to real artists, and because they are destined for slender purses demanding six portraits for six shillings. But, it seems to us, in a great many cases that the photograph might very well serve as the sketch for the painter. It is to be regretted that good artists do not oftener make use of it.

Fig. 33 represents a photographic caricature which is obtained as follows. To represent a large head on a small body a picture of the head alone is first taken and

then a picture of the entire body on a much smaller scale. Proofs are taken on paper from the two negatives, and then the large head is cut out and pasted on

Fig. 33.



PHOTOGRAPHIC CARICATURE.

to the shoulders of the figure on the smaller scale. If the large head does not fit very well on to the small body the neck is touched up with a brush. A photograph is

then taken of the picture thus obtained, and the negative produced will furnish any number of caricature proofs.

Similar processes to that just described are often made use of for the production of political photographs. A new ministry comes in, and in a day or two photographs are on sale everywhere of its members in council. It is certain the august body has not devoted one of its 'sittings' for the purpose of being photographed. How then is the picture obtained? Nothing more simple. Some enterprising photographer seats a number of his friends round a large table covered with a green cloth; on a background a handsome marble mantelpiece and a splendid chandelier are painted to represent the ministerial room. He takes a photograph of this scene, obtains a positive proof on paper, cuts out the heads of the models, and inserts in their places the heads of the new ministers cut from their carte-portraits. After being touched where necessary with the brush, a new photograph of this composition is taken and the thing is done. The interview between Bismarck and Thiers was 'photographed' in this way.

Photography offers, indeed, a mine of pleasant diversions for the observer; but we shall not go into this branch of the art which we are studying from a practical point of view.

We can only add, to keep within the limits of this chapter, that careful artistic retouching helps to improve the photograph by giving the portrait the true aspect of the human face.[1]

'Madame de Staël,' says our witty writer M. Legouvé, 'died talking; for several days her relatives seeing the fatal end approaching endeavoured in vain to keep visitors from her bed of agony: "Let them come in, let them come in," she cried in a feverish voice; "I thirst for the human face!" This profound and almost terrible saying expresses one of the most ardent passions of our time; we have all a thirst for the human face. Stop before an exhibition of photographs or prints, watch the crowd which presses round, and note its inquisitive attention. . . . Is this pure curiosity? Simple love of diversion? Frivolous idleness? No. . . . We thirst for the human face, because we thirst for the human mind.'

The desire thus referred to by M. Legouvé is real, and certainly no one would question its bearing on photography; therefore we say to the retouchers: 'Give us the human face.'

[1] This would almost seem to be a left-handed compliment to photography if the author had not already convinced us of his profound admiration of the art and its capabilities. For my own part I think that photography in the hands of a skilled and artistic operator is capable of producing results which can never be improved by retouching.—Ed.

CHAPTER VI.

ENLARGEMENT OF PROOFS.

APPARATUS EMPLOYED FOR ENLARGING NEGATIVE PROOFS—WOODWARD'S SYSTEM—MONCKHOVEN'S APPARATUS—UNIVERSAL SOLAR CAMERA.

IT often occurs that photographs of the natural size of objects are required. But to obtain a large negative, say a yard square for example, by the ordinary process is next to an impossibility. How could a plate of such a size be properly cleaned, how coated with collodion, how could the developing liquid be applied?[1] By the usual processes it may be said that such manipulations would be completely impossible even to the most expert operator.

[1] Plates a yard square and even larger are manipulated by the Autotype Company and other photographic firms in London.—ED.

The best means of obtaining a picture approaching the natural size of the object seems to consist in the enlargement, by optical apparatus, of a small negative which has been obtained as perfect as possible.

The ordinary method of enlarging consists in projecting the image of a negative plate by means of the lens of a *megascope* on to sensitised paper, where it is fixed. The Image, enlarged like that of the magic lantern slide, is faithfully reproduced on the photographic paper.

Though the theory of this operation is simple enough, its practice is somewhat difficult and requires a very perfect instrument. Mr. Woodward's apparatus consists of a large wooden case containing the negative, the image of which is powerfully illuminated and projected with the required degree of amplification on to the photographic paper.

M. Monckhoven has improved this system by adapting a second lens to the megascope which corrects the spherical aberration. The negative is held in a frame (fig. 34), the enlarging lens is contained in a metal tube, and the enlarged image is thrown on a screen at some yards' distance from the apparatus.

The illustration (fig. 34) shows the general appearance of the apparatus. On the right of the drawing will

be seen a thin partition which separates the operating room from the outer air. This room should be exposed to the south. The enlarging camera is fixed to an opening in the partition, through which a powerful light is thrown by means of a reflector which follows the sun outside, and transmits the rays through a large lens which condenses them on to the glass negative to be enlarged; after passing through the negative it next traverses the enlarging lens, carrying with it the image to be reproduced, and thrown in the required size upon

Fig. 34.

MONCKHOVEN'S ENLARGING CAMERA.

the screen fixed at some yards' distance.[1] This distance should be about three yards to obtain a photograph one yard in diameter.

Fig. 35.

LIÉBERT'S ENLARGING APPARATUS.

M. Liébert has invented an enlarging apparatus which has advantages over the preceding. It is much more economical and does not require any special

[1] The size of the enlarged image also depends on the focal length of object-glass.—ED.

fixed position. It can be used from sunrise to sunset, which is not the case with the apparatus illuminated by reflection which we have just described. The illustration (fig. 35) gives such a clear idea of Liébert's apparatus that any description is unnecessary.

Success in the enlargement of photographs can only be obtained when the greatest attention has been paid to the preparation of the small glass negative, which requires a special method.

A thin, quite transparent glass plate should be chosen with a perfectly smooth surface. Liquid collodion must be used, to ensure sufficient transparency to the image to be enlarged.

The negative must be very transparent; therefore it should not be too vigorous or intense. To arrive at this result such substances are avoided in the preparation of the developer as tend to intensify. The sulphate of iron solution in alcoholised water is alone sufficient.

The negative having to be exposed to the sun's rays should not be coated with any varnish which melts under the action of heat.

The art of enlarging photographs has been brought to great perfection during the last four years.[1] Some

[1] The enlargements obtained in London by the Autotype process appear to me to leave almost nothing to be desired. The method followed in their

operators have arrived at results worthy of the highest praise.

Enlargements, it is true, offer certain inconveniences; the details of the enlarged proof have often a disagreeable effect ; they are exaggerated and seem as though seen under a magnifying glass. It would, however, be unjust, in spite of these defects, to underrate the importance of the results obtained.

production is totally different from any of the processes described by the author. The most beautiful carbon transparencies are first taken from small negatives, and are used in the production of large negatives on glass plates by the wet collodion process.—ED.

CHAPTER VII.

PROCESSES.

THE DRY-COLLODION PROCESS—EMPLOYMENT OF ALBUMEN, HONEY, AND TANNIN—WAXED-PAPER PROCESS—PERMANENT PHOTOGRAPHY BY THE CARBON PROCESS—METHODS OF POITEVIN, SWAN, ETC.

THE wet-collodion process, which we have described at some length, gives excellent proofs, very sharp, and often of an astonishing degree of perfection; but it has one great drawback. As soon as the glass plate is coated with collodion it must be at once exposed in the camera. If it is allowed to dry, it is no longer so impressionable. As the collodion dries very rapidly it is very difficult to make use of it in landscape work, or in any way in warm climates.[1]

[1] My own experience when travelling in the tropics does not bear out the author's views on this point. Dry plates as we find them now-a-days, nearly, if not quite equal to wet plates in their sensitiveness, are greatly to be desired by the photographer who may happen to be exploring a new country. Yet I have found the old wet collodion process in the tropics always so ready and always so capable of responding to my every wish, that I esteem it above all others. By certain simple modifications, such as adding alcohol to the collodion, a wet plate may be freely exposed for half-an-hour in a climate where the temperature is 90° in the shade.—ED.

It had long been the endeavour of photographers to discover a means by which plates coated with collodion and allowed to dry could still be made to retain their sensibility to light. The problem has been solved by the addition to the collodion of gummy or resinous matters, so that instead of the film being impervious, it should, on the contrary, remain porous, so as to absorb the sensitising liquid when required for use, a few moments before its exposure in the camera.

Dry collodion.—The reader will remember that albumen was employed in photography until the discovery of collodion. It is still made use of by some operators in certain cases, and gives very good results.

The albumen process.—A well cleaned glass plate is coated with ordinary iodised collodion; after being sensitised and washed to remove free nitrate of silver the collodion is again coated with albumen containing iodide of ammonium, ammonia, and sugar candy.

The plate thus covered with a liquid which preserves the collodion beneath it is dried and then placed in a grooved box which is perfectly air-tight. When the plate is required for use, it only remains to sensitise it in the silver bath, and the concluding operations of washing and drying are effected in the ordinary way.

The time of exposure in this process is somewhat

long; to obtain good results the directions of its inventor, M. Taupenot, must be scrupulously followed.

The cleaning of the glass requires to be even more carefully done than in the wet-collodion process. After spreading the collodion on the plate, it is sensitised in a neutral nitrate of silver bath. The plate is drained and then recoated with the preparation of albumen or white of egg. To prepare the latter it is sufficient to pour some whites of eggs into a glass, and after adding a few drops of ammonia and a little iodide and bromide of ammonium, to beat up the mixture well. The addition of sugar candy is useful; it keeps the albumen fluid, and allows of its being easily spread over the plate as with collodion. The plate once albumenised is dried, away from light and dust, and may be used very advantageously five or six hours after being prepared.

A number of plates are prepared in this way, and when required for use they are sensitised in a nitrate of silver bath to which a little acetic acid has been added. They are developed with gallic acid, and fixed with hyposulphite of soda.

The albumen process necessitates a considerable exposure in the camera; the development is not produced until the plate has been under the action of the developing fluid for about half an hour. It cannot be employed

for portraiture, but is well adapted for reproducing drawings, pictures, and engravings, as the albumen gives a very sharp negative full of harmony in tone.

The tannin process.—This process, which has been much spoken of, is due to Major C. Russell. Thanks to the persevering and ingenious experiments of this savant, it is now possible to preserve the prepared plates for a very long time without their losing any of their properties. Their sensibility is certainly much more considerable than that of plates coated in the ordinary way. Major Russell's discovery consists in combining tannin, or tannic acid, with the coating of iodide of silver, destined to be impressed with the light. The original process, which was published in 1861, has undergone considerable modifications since that time; we shall describe it with the improvements which have been successively made.[1]

[1] The tannin process is here singled out as a type of a host of other dry-plate processes which are interesting as forming links in the chain of photographic progress. An endless variety of substances may be used in place of tannin more or less successfully. Thus I myself, when I could obtain nothing better, have employed a solution of lime-juice, orange-juice, and, with varying success, ordinary bottled beer with a slight admixture of sugar. But the most modern processes, although they demand delicate manipulation, yet in their rapidity of action and beautiful results are nearly on a par with our best wet-collodion processes. As this work does not profess to furnish exhaustive descriptions of the various processes, I need do no more than give an outline of one or two of the newest methods of preparing dry plates, which do away with the use of the nitrate of silver bath.—Ed.

The plate is first coated with a special collodion containing small quantities of iodide of cadmium and

Gelatino-bromide process :—

To 1 ounce pure gelatine add 16 ounces of water. When the gelatine has absorbed the water to its fullest extent, dissolve by gentle heat, and while the solution is yet hot add 1¼ ounce bromide of potassium, stirring the mixture until the salt is thoroughly taken up. Dissolve ¾ ounce nitrate of silver in water, sufficient to make a saturated solution, which must then be next added to the bromadised gelatine. The addition of the nitrate of silver renders the solution highly sensitive to light. This and the subsequent operations must therefore be conducted in the yellow non active light of the operating room. This sensitive emulsion which alone forms the dry-plate film must be subjected to a process of washing so as to remove the free salts of the metals, which would otherwise interfere with the picture. This may be done by allowing the gelatine to set, cutting it up in small pieces and washing it in water kept running for some time, until, indeed, all traces of the free salts have been removed, and the emulsion carries only the quantity with which it has formed an intimate union in the production of bromide of silver. The sensitised gelatine may now be dissolved by gentle heat, and poured in *quantum sufficit* on the centre of a glass plate over which it is evenly distributed, placed on a level stand on a dark shelf free from dust, where it is allowed to set and dry. When dry, the plate thus prepared is ready for exposure in the camera, and if carefully preserved from daylight weeks may elapse between the time of preparation and exposure, and exposure and development. I have seen plates taken by this method almost instantaneously, but the nice timing of the exposure has hitherto proved a drawback to the wide application of the process. After exposure the plate must be soaked for some time in water, when the latent image may be brought out by what is known as 'alkaline development,' discovered by the inventor of the tannin process.

Developer, No 1.

Carbonate of Soda	40 grains.
Water	1 pint.

No. 2.

Pyrogallic Acid	96 grains.
Alcohol	1 ounce.

iodide and bromide of ammonium. It is sensitised in a bath of nitrate of silver strongly acid with acetic acid. The plate as soon as sensitised is well washed, then coated with a solution of tannin (10 parts of alcohol and 2½ to 3 of tannin to the 100 of water). This solution is poured over the plate several times, which is then washed and dried in the plate rack. It is hardly necessary to say that these operations take place in the dark room; when the plate is dry it is slightly warmed, and can then be kept for a very considerable time.

The time of exposure of these tannin plates varies from about 35 seconds to 2 minutes. Before developing the image, the plate is dipped in a weak solution of nitrate of silver till the tannin coating is impregnated.

No. 3.

Bromide of Potassium	5 grains.
Water	1 ounce.

No. 1 is the alkaline solution which is used with the addition of a few drops of Nos. 2 and 3, in quantity sufficient to flood the plate. The time of exposure and development must be determined by the experience of the operator.

Collodion Emulsion process:—

This process, while it offers more uniformity and certainty in its results, is not so sensitive as that just described in which gelatine takes the place of collodion. With the exception of collodion, the materials used and the mode of manipulating the plates are almost identical with those employed in the gelatino-bromide process. The reader who is anxious to study the collodion emulsion process will find detailed descriptions in the *British Journal Photographic Almanac* for 1875.—Ed.

It is then drained and the picture developed with a solution of pyrogallic acid and water, and a little alcohol and glacial acetic acid. If the image requires intensifying, a weak solution of citric acid mixed with a small quantity of nitrate of silver added to the developer will give excellent results. The plate is then well washed and fixed as usual with hyposulphite of soda.

M. Legray is the inventor of the waxed-paper process—an interesting and useful process, of which the following is a succinct description.

The paper which is to be coated with wax must be formed of a uniform and homogeneous pulp, well-sized, and must be thin, as the proof has to be seen by transmitted light. The operation of waxing is very delicate. The paper is spread out on a metal box filled with boiling water, which is maintained at 100° by placing it on a fire. The leaf of paper is protected from contact with the metal by intermediate sheets of blotting paper; it is then rubbed with white wax which sinks in as it is spread. As soon as the first leaf is well impregnated all over its surface, a second sheet of paper is placed on it, and rubbed with wax in the same way, then a third, a fourth, and so on till twelve have been done. These twelve waxed sheets are interleaved with twelve unwaxed sheets, and then the whole packet is

energetically rubbed first in one direction, then in another. The excess of wax in the twelve sheets prepared passes into the other twelve sheets, thus giving twenty-four sheets saturated with wax. Each leaf is now rubbed separately, one by one, with a silk rubber, and when a well-rubbed leaf is smooth, transparent, and does not exhibit white or brilliant spots, indicating a want or excess of wax, it can be kept for an indefinite time.

The waxed papers thus obtained are plunged into a solution of iodide of potassium in rice and water.[1] When removed from the bath and dried, they are placed between two sheets of blotting paper, and rubbed warm with a hot iron.

The iodised waxed paper has a violet tint; it must be preserved from contact with damp or air. When it is required to sensitise the paper before use, it is plunged in a bath of nitrate of silver to which acetic acid has been added.[2]

[1] To 35 oz. of Water,

1,000	grains of	Rice.
750	,, ,,	Sugar of Milk.
225	,, ,,	Iodide of Potassium.
75	,, ,,	Bromide of Potassium.

[2]

Distilled Water	1 ounce.
Nitrate of Silver	30 grains.
Glacial Acetic Acid	40 minims.

The paper is exposed in the camera by being fixed between two glass plates. The time of exposure is usually about one hour, sometimes more; it can only be determined by experience.

The development of the picture is accomplished by the aid of gallic acid, to which nitrate of silver and acetic acid are subsequently added. The leaf of paper is completely immersed in the developing bath until it has acquired the desired intensity.

It is fixed as usual with hyposulphite of soda.

When washed and dried the paper is rendered again transparent by rubbing with a hot iron, after being covered with a piece of tissue paper.

Besides M. Legray, Messrs. Vigier, Baldus, and others have prepared albumenised and gelatinised papers which give equally good results, and as formulæ for obtaining negatives on waxed paper abound, we refer the reader who may be curious in this regard to the published works of these inventors.

The permanent carbon process.—The processes we have hitherto described furnish prints more or less liable to fade. Whatever the cares and precautions of the operator, however well it is washed, the positive proof is destined after a certain time to tarnish, to

become yellow, and even to disappear. How, indeed, could it be otherwise, when it is formed by the reduction of metallic salts, made up to a certain extent of fugitive chemical agents. This serious drawback gave rise to the desire for some means of imparting durability to the photograph, and to assure it the same permanency as typographical proofs and impressions in general which are obtained with an ink made with some permanent basis, such as carbon. &c.

The term *carbon print* is applied to photographic impressions obtained by the aid of some fixed or unalterable matter, carbon or other permanent mineral substances. The various processes for producing positive carbon prints are based on the principle indicated by Alphonse Poitevin in 1855.

This learned experimentalist, of whom we shall have to speak further in our chapter on *Heliography*, and to whom the photographic art is indebted for a great number of most important improvements, discovered that the action of light on gummy or mucilaginous matters mixed with alkaline or earthy bichromates renders them insoluble, even in warm water: it then occurred to him, for the purpose of producing permanent photographs, to add some insoluble colouring matters, such as carbon or pow-

dered enamels, to gelatine, albumen, gum arabic, sugar, starch, &c.[1]

A fine coating of bichromatised gelatine, mixed with carbon, is spread over a leaf of paper and exposed to the impression of the light through a negative. After the insolation, the paper is washed in tepid water; the parts of the picture unaffected by the light (*i.e.* those parts which have been protected by the denser portion of the negative) are dissolved, whilst those parts which have been rendered insoluble by the action of light remain adhering to the surface, and the picture appears, formed by the insoluble parts of the mucilage. Since this first indication of the process by M. Poitevin, published more as a curiosity than as a practical method, a great number of operators set themselves to study the new phenomena brought to light. Laborde, Garnier, and Salmon at Paris, Pouncy at London, and others, were not long in conceiving similar processes to that of M. Poitevin, all of them more or less perfect. In 1864, Mr. Swan gave a vigorous new start to the art of permanent carbon photography; and shortly afterwards, Mr. A. Marion popularised the new process by some truly remarkable productions.

[1] Photographie au charbon. Recueil pratique de divers procédés des épreuves positives formées de substances inalterables, par L. Vidal. Paris. 1869.

The following extract from the *Moniteur de la Photographie* describes Mr. Swan's curious process :—' In 500 cubic centimètres of cold water, allow 1,800 grains of gelatine to swell for some hours, then dissolve with a gentle heat. Add a white of egg beaten up, stir well and heat till it boils, and then filter. By this means the albumen is clarified and becomes brilliant and limpid. The amount lost by evaporation is made up with water, and 900 grains of white sugar added. Indian ink as colouring matter is now mixed with it, after being powdered or dissolved in water. The gelatine is kept in well stoppered bottles. To sensitise it, a solution of bichromate of ammonia (450 grains to 1,350 of water), is prepared and added to the coloured gelatine in the proportion of 450 grains to 3,000 or 4,500 grains of gelatine. A glass plate is next coated with non-iodised collodion of a proper consistency: this, being evenly spread over, is allowed to dry perfectly. The plate is now warmed and coated very evenly with the sensitised gelatine solution, which soon sets; when quite dry, this film can be detached by passing a penknife along the edges, and presents the appearance of a piece of varnished leather, black in colour, and flexible. It is nevertheless translucent, and by examination, it is easy to determine if it is of a proper colour. This film must be kept in the dark, and employed within

one or two days. To print on it, it is placed in contact with the negative, the collodion side next the film, so that by exposure to the light the impression is formed on the inner face of the sensitised gelatine. The time of exposure naturally varies according to the intensity of the light, and the density of the negative; but, in any case, it will not exceed the third or the fourth of that required with the nitrates of silver. The range is much larger than with the ordinary processes, and prolonged exposure does not materially affect the picture. The print is then mounted on paper with starch or india-rubber. When dry it is plunged into water, heated to 40° Centigrade. The gelatine unaltered by the light soon dissolves, leaving the picture with all its gradations of tone adhering to the collodion. When the print has soaked for about two hours it can be fastened to another sheet of paper, to straighten it, and when dry the first sheet may be readily removed. The print when finished possesses great delicacy, and is of course glazed with the film of collodion in front.'[1]

[1] Carbon prints taken by the above process are as fine in gradation, vigour, and sharpness as the best silver prints. There seems, however, to be some risk of their destruction, in consequence of the collodion film cracking. The process is patented (No. 503, February 29, 1864). Some specimens submitted to the public by the patentee are not inferior to the very finest photographs upon paper that have ever been seen. *The Dictionary of Photography.* Low & Co. 1867.

Since Mr. Swan's improvements the so-called *carbon processes* have made great strides, and admirable results have been arrived at. According to the nature of the permanent and solid substance which is incorporated with the gelatine, the glazed tissue can be toned black like an engraving, purple, or sepia colour.

The colouring matter, of whatever nature it may be, is first ground to an impalpable powder, and the gelatine, dissolved in warm water and well filtered, is added in small doses (3,000 grains of gelatine to the litre of water = 1·76 pint). The mixture is then stirred till perfectly homogeneous.

A sheet of paper of good quality is next damped and placed on a glass plate in such a way that by the means of four small rules the four edges of the paper can be turned up to the extent of not more than three or four millimètres, a very shallow dish being thus formed, into which the gelatine solution is poured so as to flow perfectly horizontally. The solution soon solidifies: the gelatine film is then lifted from the glass and allowed to dry spontaneously.

The gelatine films are sensitised by immersion in an aqueous solution of bichromate of potassium (of 5 p. 100). To take an impression, one of them is applied to the back of a photographic plate, and is then

exposed to the light. When a negative is used to print from, the picture will be reversed, and it is for this reason that a provisory support should be employed, which can be easily taken from the positive picture when desired. We refer the reader who may wish to master all the details of this process to Mr. D. B. Monckhoven's work,[1] only allowing ourselves to give here the principle of a new branch of the art which we are studying. The practical details would take us too far from our plan, which comprehends all the numerous chapters of the book of modern photography.[2]

[1] Published by G. Masson. Paris. 1873.

[2] The carbon process, in its most recent forms, has attained to that degree of perfection, certainty, and facility of manipulation which renders it a most formidable rival to silver printing. Photographers have not been slow to acknowledge its superiority over all other processes in the production of the most delicately beautiful enlargements from small negatives. But it is only within the past month or two that the carbon process has proved capable of producing small prints equal in every way to the best silver prints.

In common with all the other permanent photographic printing processes, whether the proofs are obtained by exposure to sunlight or mechanically, the carbon process starts from the basis supplied in the insolubility resulting from the exposure to solar light of a mixture of gelatine and bichromate of potash. But in order to render this chemical action available for the purposes of the carbon printer, the gelatine and bichromate of potash must be charged with some permanent colour in a fine state of division, as in Swan's process. In place, however, of employing collodion as the support for the tissue, the Autotype Company at Ealing Dean simplified the method of producing tissue by using paper as the support and by introducing machinery into its manufacture. This company held various patents which have been transferred to Messrs. Spencer, Sawyer, Bird & Co., to whom we are mainly indebted for rendering the carbon process of practical

commercial value. They now manufacture tissue of all shades of colour, ready for the simple operation of sensitising by floating on a solution of bichromate of potash. While confining my observations to one or two topics relating to carbon printing, I must refer the reader for detailed information to the manual of practical instruction published by the above firm.

A carbon print may be taken from an ordinary negative by exposing the sensitised tissue beneath the negative as in ordinary silver printing. No visible image will result from this exposure : the image is nevertheless imprinted in the tissue, or rather, the light has imparted to the surface various degrees of insolubility, which, in their intensity, correspond exactly with the shadows and half-tones of the picture. In other words, where the action of the light is strongest, the sensitive film elects to form a close and indissoluble union with the carbon. When the light has only partially affected the tissue the union is weak, and it readily, when treated with warm water, yields up part of the colouring matter, and where the light has not exercised its subtle influence in the faintest degree, the colouring matter may be dissolved out, leaving the paper white.

The printing of the picture must be timed by the use of a simple actinometer made for the purpose. In order to develop the print it is necessary to immerse the tissue in a bath of water and to place it in intimate contact with a sheet of transfer paper. The tissue and its new support are then laid in a bath of tepid water, when the original support will float off and the picture gradually reveal itself. This simple operation of washing with water removes all the free unaltered carbon, and leaves a bright and beautiful impression on a permanent support. In the case of negatives which are not reversed, a double transfer must be effected by placing the tissue for development on a temporary support of glass or zinc. Specially prepared tissue, mounted and developed on a glass plate, not only produces a transparency full of the most beautiful gradations of light and shade, but so exceedingly minute in its details as to enable the operator to take from it a perfect negative, enlarged to three or four times the diameter of the original. I know of no other transparency to be compared with it in the making of large negatives from small ones.

This peculiar adaptability of the carbon transparency for copying or enlarging negatives has rendered it of the greatest value, as it enables the carbon printer to make a reversed negative so absolutely identical with the original as to permit him to print his proofs by single transfer.—ED.

CHAPTER VIII.

PROBLEMS TO BE SOLVED.

THE FIXING OF COLOURS—A MYSTIFICATION—EDMOND BECQUEREL'S EXPERIMENTS — ATTEMPTS OF NIEPCE DE SAINT-VICTOR AND POITEVIN—PHOTOGRAPHIC PRINTING.

WE have seen how and by what processes the photographic art arrived at fixing the image of the camera on paper: the results obtained, though marvellous as they are, are susceptible of being improved, like all human work. We think it will be interesting if we glance at some of the improvements which it is possible to hope for in a near future.

Photography reproduces nature; the picture which it furnishes is the image of the mirror, but the image without colour. To find a photographic process susceptible of giving coloured proofs, and capable of reproducing the colours as it does the aspect and form of natural objects, would seem to be the criterion of photographic power: on the face of it, the problem appears insoluble. It is not necessary to be versed in the study of physics

to understand the difficulties in the way. It is necessary to find a substance which should be influenced in different ways by the different rays of the spectrum, and which could reproduce the proper colour of each luminous ray; the search for such a chemical as this would seem to be comparable to that for the philosopher's stone. However, in the presence of certain facts already obtained by some savants of note, it would be imprudent to deny the possibility of such a problem; its solution is perhaps nearer than we are in the habit of supposing. A few lights are already shining in the direction of this goal, hidden in the bosom of the unknown. Will they be useful or fruitless? Will they open up a new road or remain isolated and sterile? Until we have passed in review the results already obtained we cannot reply.

It may be well, before studying the real experiments made by some of our most eminent scientific men, to narrate one or two facts, interesting from an historical point of view, which made a great stir at the time. In 1851, the photographers of Europe were all thrown into a state of excitement by an extraordinary announcement which came from the other side of the Atlantic. The American papers affirmed that a Mr. Hill, a photographer, had discovered the means of reproducing the

images of the camera with their natural colours. For the time nothing was spoken of but this illustrious inventor, and for the moment his name became as renowned as that of Daguerre. This Mr. Hill was a reverend pastor who was no enemy to puffing: he had launched the news of his invention in all the American papers, and had nothing to complain of in the enthusiastic epithets which were applied to his discovery. Mr. Hill, all at once, soared like a rocket to the topmost steps of the ladder of fame. The cute pastor allowed public curiosity to ferment well. 'When he saw things were ripe,' says Mr. Alexander Ken, who relates the story, 'he issued a circular promising shortly to publish a work which should divulge the secrets of his discovery. The author added that this work would only be circulated to the extent subscribed for by photographers, and that it would be forwarded to all those who sent him their address with five dollars. A testimonial, signed by several persons, set forth that Mr. Hill was a respectable ecclesiastic worthy of all confidence.

'The circular produced fifteen thousand dollars. The volume appeared: it consisted of about one hundred pages, and cost the author about twopence a copy. But if it was dear, it contained nothing but a few commonplace descriptions of the well-known daguerreotype

process, and said not a word about the reproduction of colours!' [1]

Mr. Hill afterwards published a second and a third brochure, but the public had had enough of Mr. Hill and his works. The subscribers swore, but a little too late, that they would not take them.

M. Edmond Becquerel was the first who reproduced the image of coloured rays. He succeeded in printing the seven colours of the solar spectrum on a silver plate. His works when made known were appreciated at their real value by men of science. M. Becquerel plunged a plate of silver in hydrochloric acid diluted with water; he attached the metal to the wire of an electric battery. Under the influence of the electric current the silver became coated with sub-chloride of silver, of a characteristic rose colour. On being taken from the bath, washed and dried, it was sufficient to expose it to the rays of the solar spectrum: the seven colours were then delineated, with their corresponding gradations. Unfortunately, up to the present no means have been discovered for fixing these colours: they disappear when exposed to daylight, and must be preserved in the dark.

'M. Niepce de Saint-Victor also attempted to solve this great problem of the fixation of colours, but he was

[1] *Dissertation on Photography.* A. Ken. 1864.

foiled in his attempts. He succeeded, however, in obtaining photographic proofs of blue, red, and green colour. These coloured photographs have a very pretty effect. Although somewhat more stable than formerly, they are still affected by prolonged exposure to light: the processes are, however, already much improved, for the proof which M. Niepce obtained at the commencement of his researches could not stand the slightest exposure to daylight. It is due to the employment of salts of uranium that it has been possible to solve this interesting question.

'To obtain a red-coloured proof, for example, he prepared the paper with a solution of azotate of uranium of 20 to the 100 of water: this paper is dried in the dark, and exposed for a time, varying in length according to the intensity of the light; the proof is then washed in water of 50° or 60° Centigrade, and subsequently dipped into a solution of cyanoferride of potassium of 2 to 100. After a few minutes the print assumes a beautiful blood-red colour; it only remains to wash it well in water several times changed and dry it. The red print thus obtained becomes green if dipped in a solution of azotate of cobalt, and not washed; the green colour appears by drying at a fire; it is fixed by immersion for a few seconds in a solution of sulphate of

iron and sulphuric acid, each in proportion of 4 to the 100 of water; it is then well washed and dried at the fire. A violet colour may be obtained by washing in warm water as soon as taken from the printing frame, and by developing with chloride of gold of $\frac{1}{2}$ to the 100 of water. To obtain blue prints the paper is prepared with a solution of cyanoferride of potassium of 20 to the 100 of water; after exposure under the negative it is washed for ten seconds with a solution of bichloride of mercury, saturated cold; a solution of oxalic acid at 60° is next applied, and the print is then well washed and dried.'[1]

In 1866 M. Poitevin made a series of curious experiments relating to the grand problem of fixing colours. 'On a paper covered previously with a coating of violet chloride of silver, which he had obtained by exposing white chloride to the light, and in presence of a reducing salt, a liquid is applied formed of a volume of saturated solution of bichromate of potassium, a volume of saturated solution of sulphate of copper, and a volume of solution of 5 to the 100 of chloride of potassium; the paper thus prepared is allowed to dry, and must be kept away from light. The bichromate of potassium may be replaced by chromic acid, or by azotate of uranium.

[1] *Annuaire scientifique de M.P.P.* Dehérain. Paris. 1862.

With this paper, which is, so to speak, *supersensitised*, the exposure to the direct action of the light is not more than from five to ten minutes when it takes place through paintings on glass, and one can very well follow the appearance of the image in colour. This paper is not sufficiently impressionable to allow of its employment in the camera; but, such as it is, it gives coloured reproductions in a special enlarging apparatus.'[1]

These photochromos may be preserved in an album, if the precaution is taken of washing them first in water acidulated with chromic acid, then in water containing bichloride of mercury, again in water charged with nitrate of lead, and finally in pure water. In this state, they will remain unaltered if kept from the light.

[1] The problem of obtaining polychromatic photographs is still far from being solved. More enthusiasts than one have imagined that they have discovered a clue to the mystery in the beautiful prismatic colours produced by a thin film of air imprisoned beneath the collodion of an imperfectly cleaned plate. Some eight or ten years ago these aspirants to fame used to write to the photographic journals, proudly refusing to confide in the public until they had taken such steps as would enable them to engross to themselves the entire credit of their discoveries.

Monochrome photographs may be obtained in a variety of ways, but such prints, unfortunately, bring us no nearer to photography in natural colours. M. Vidal's prints were probably similar to some I have seen in Paris, produced by an ingenious mechanical trick which the photographer was in no way careful to conceal.

As far back as 1810 Seebeck discovered that chloride of silver, when subjected to the rays of the spectrum, partook slightly of the different colours. Violet produced brown, blue a shade of blue, yellow preserved the paper white, and red imparted a red tint to the chloride of silver. —ED.

Unfortunately, these new photogenic pictures are hardly more stable under the action of light than those obtained previously by Messrs. Becquerel and Niepce de Saint-Victor.[1]

In the photographic exhibition in the Palais de l'Industrie in 1874, a number of polychromic prints were exhibited by M. Vidal, which have the advantage of being permanent. But the colours affect principally the shadows, and are almost invisible in the details. M. Vidal employs papers which he superposes to give birth to each colour; but the tints and half-tones are very indefinite.

The result of these curious experiments shows plainly that the fixation of colours by photography is one of the most difficult problems which modern science has to solve. Though but a very short portion of the road towards the great end has been opened up, still it would be wrong to despise what has been done or to regard the final solution as an altogether Utopian or chimerical problem.

As M. Niepce de Saint-Victor says, 'If the problem of the fixation of colours is not yet solved, one may, at least, hope that it will be.'

[1] Louis Figuier, *Les Merveilles de la Science.*

This is evidently one of the greatest questions the art of Daguerre has to solve. There is another of high import, namely, the transformation of the negative into an engraving plate; we shall refer to this in the first pages of our third part.

PART III.

THE APPLICATIONS OF PHOTOGRAPHY.

CHAPTER I.

HELIOGRAPHY.

THE DAGUERREOTYPE PLATE TRANSFORMED INTO AN ENGRAVING PLATE — DONNÉ — FIZEAU — THE PHOTOGRAPHIC ENGRAVING OF NIEPCE DE SAINT VICTOR—PHOTO-LITHOGRAPHY AND HELIOGRAPHY[1] INVENTED BY A. POITEVIN—PROCESSES OF BALDUS, GARNIER, ETC.—THE ALBERTYPE—OBERNETTER'S PROCESS—MODERN HELIOGRAPHY.

FROM the origin of photography, even in Daguerre's time, it had been a matter of regret that the beautiful picture produced by light at the focus of the camera was condemned to remain as an unique type; it was asked if the art would not eventually be able to produce from the negative an engraved plate capable of being used for printing on paper in the ordinary way. At the present

[1] For a description of the modern *Heliotype Process*, which is successfully worked by the *Heliotype Company* of London, see Appendix.

day these hopes have been in part realised ; if it has not yet arrived at the degree of perfection which will most probably be characteristic of heliography in a near future, it has yet been found possible to change the negative into a metallic plate similar to that used by the engraver on steel or wood.

It was the noted *savant* M. Donné who first entertained the idea of acting on a daguerreotype plate with hydrochloric acid, so as to 'bite' the negative in the light parts, and to leave the shadow and half-tones in different degrees of relief, and thus to produce a plate capable of giving prints on paper in the common printing-press. But the mercury employed in the daguerreotype process is not always equally distributed over the silvered copper-plate, and it is often only of an extraordinary thinness, so that the parts etched by the acid are so extremely shallow as to give but very insufficient relief to the rest ; besides which, the parts left in relief being formed of silver, a very soft metal, allows but a limited number of impressions being taken. The early heliotype plates were worn out and useless before fifty prints on paper, and these still very imperfect, had been taken from them.

Fizeau improved this rudimentary process, but he so complicated the operations as to make his method prac-

tically useless. He succeeded in attacking the shadows and darker parts of the daguerreotype plate, whilst leaving the whites formed by the mercury in relief. But the chief essential in a good engraving is depth in its reliefs ; the grooves and cavities opened by the acid must be deepened. Fizeau effected this in the following way : he filled the grooves and hollows with a greasy oil, which did not adhere to the parts of the plate in relief. The latter he gilded with a battery, and then removed the oil contained in the grooves, and by aid of nitric acid the latter could now be made as deep as desired, the salient parts of the plate being protected by their covering of gold.

After these ingenious labours of Fizeau, photography on paper was discovered, and heliography seemed likely to lose its interest. It was not long, however, before this problem of photographic engraving was recognised as worthy in all respects of fixing the attention of enquirers. It is true that by the process of photographic printing on paper one has at once a negative on glass which will produce any quantity of proofs ; but how slow is the printing ! what numerous obstacles there are in the way of this process, which requires sunlight and careful attention to minute detail unknown in the production of printing-press proofs ! and besides, photography on paper

is not durable; it fades with time, sometimes turns yellow, and often even becomes completely effaced.

Photographic engraving was again studied with activity. Talbot and Niepce de Saint Victor succeeded in engraving transparent objects on steel by the aid of photography. They employed bichromate of potassium as their sensitising agent; but their results were coarse and devoid of all artistic value.

In 1853 M. Niepce de Saint Victor published a method of transferring a photographic negative on to steel, based on the first process of his relative, Nicéphore Niepce.

His method was as follows:—A steel plate well cleaned and polished is covered with a coating of bitumen of Judea, which is spread on the metal by being previously dissolved in essence of lavender.[1] This coating is dried in the dark room, so as not to be affected by light. That done, a glass positive is applied to the metal plate thus sensitised, and the whole is exposed to the light, which acts on the bitumen through the transparent parts of the positive. The exposure must be continued for about fifteen minutes. The glass plate is then taken off the

[1] According to Mr. Monckhoven, the bitumen of Judea or asphaltum best for these operations should be completely insoluble in water; it should dissolve in the proportion of 5 to the 100 in alcohol, of 70 to the 100 in ether, and entirely in essence of turpentine, in pure benzine, and in chloroform.

steel, and the latter with its coating of bitumen is washed in a mixture of benzine and naphtha oil, which dissolves only those parts of the coating which were protected from the action of the light by the opaque parts of the photographic positive.

The parts of the steel plate laid bare by the solvent can be bitten in with nitric acid, and the rest being thus left in relief, the plate may be used for printing with ink on paper, and produces an exact copy of the photograph. These engravings of Niepce de Saint Victor were not without a certain merit, but, on the other hand, they possessed grave defects; the shadows, particularly, present no gradation or detail, being mere uniform blots which converted the engraving into little more than a coarse outline. It was in vain that M. de Saint Victor endeavoured to improve his process; he shortened the exposure and took impressions direct on to the steel plate by means of the camera, but all to no purpose, and after years of persevering research he was unable entirely to overcome the difficulties in his way.

Whilst M. Niepce de Saint Victor was thus attempting the solution of his difficult problem, M. Poitevin, an engineer of note, of whom we have already spoken, opened up new and unexpected horizons in the domain of photographic engraving. Since 1839, Poitevin, struck

with the report read by Arago on the fixation of the image of the camera, had been an ardent disciple of Daguerre; but his work as an engineer prevented him from immediately occupying himself with the study of the interesting problems which he hoped ultimately to solve. 'In 1842,' says Poitevin, 'whilst experimenting with electrotypy for reproducing the images formed on the silver plates, I had observed that the daguerreotype plate, on being taken from the mercury fuming box, and bearing on its surface the representation or image of which the whites were formed by the amalgam of silver, and the blacks by the iodide of silver unaltered by the light, received a deposit of copper on the white parts only, without the blacks or shadows being affected, when plunged in the electrotyping bath; of this, which was my first discovery, I made repeated trials, all of which succeeded; but, forced to suspend these distractions (for at that period they were nothing more to me), and devote myself to my career of engineer, it was not until 1847 that I was enabled to take them up again as serious studies. I applied my observations on engraving with acids to the transferring on metal of the ioduretted designs of M. Niepce de Saint Victor, then to daguerreotype images on double silvered plates, and soon after to the transformation of daguerreotypes into negatives capable of being

used for printing in the ordinary way on papers sensitised with nitrate of silver.

During twenty years Poitevin laid the first foundations of several distinct methods, all of which have their originalities and applications. These processes were for a long time very little known, but, happily for science, the inventor at the end of his career decided to publish all the methods which he employed in a *brochure*, which is now very rare, entitled 'Treatise on Photographic Impression Without Nitrate of Silver.' 'This *brochure*,' as one of his biographers truly says, 'is not a manual, nor a treatise, nor a book; it is more than all this: it is the *résumé* of the persevering studies of a man who, knowing many things, for twenty years applied all his knowledge to the realisation of a single object—the progress of an art which he loved passionately, and of which from the commencement he understood the true destiny.'

The first method worked out by the clever operator, which may be called the galvanoplastic or electrotype method, is as follows.

A photograph is taken by the daguerreotype process. When the picture has been developed with the mercury fumes, without removing the unaltered iodide of silver, the plate is attached to the negative pole of an electric

battery, and plunged in the electrotype bath. The deposit of copper takes place only on those parts of the plate which are not protected by the non-conducting coating of iodide of silver.

This operation finished, the plate is next washed in a solution of hyposulphite of soda, which removes the iodide of silver, and lays bare the metallic silver beneath. In the electro thus obtained the lights of the picture are covered with copper, the shades are formed by the silver of the plate. The plate is then gently heated to oxidise the copper, and quicksilver is spread over it. The liquid metal amalgamates only with the silver, leaving the oxide of copper bare. Next the plate is covered with gold leaf, and the same phenomenon is reproduced; the gold adheres only to the amalgamated parts, which, it must be remembered, represent the shades of the picture. The lights still remain indicated by the oxide of copper. This partial gilding of the plate being accomplished, it only remains to subject the plate to nitric acid or aquafortis; the acid attacks the plate wherever it is unprotected by the gold coating. By this means the shades of the picture, represented by the gold-coated parts, are left in relief, and thus a plate is produced capable of being used for typographic printing.

After the first attempts Poitevin directed his ex-

periments in quite a new direction; he transferred the photographic proofs not now to metal but to stone, and his ingenious method was invented under the name of photo-lithography.

PHOTO-LITHOGRAPHY.—On a stone of good grain and quality, Poitevin spread a mixture of albumen and bichromate of potassium. He placed on this surface a photographic glass negative, and then exposed the whole to the light. The light, as we have already explained, only acts through the transparent parts of the negative. By this means, that is, by the mysterious influence exerted by the light on the gelatinous or gummy bichromate coating, the stone is made capable of retaining printing ink. As soon as the glass negative is removed, the surface is moistened with water, an inking roller is passed over the stone, and the ink only adheres to those parts of the coating on its surface which have been acted upon by the light. The original photograph thus becomes a lithographic stone.[1]

[1] See Poitevin's work, 'Photographic Impression Without Nitrate of Silver.' Paris 1862.

We will complete this summary description with the following passage, extracted from the report of the photographic commission charged to examine the photo-lithographic process :—

'If an ordinary lithographic stone is covered with an albuminous solution mixed with bichromate of potash, and if this liquid is allowed to dry spontaneously, the albumen, however much it may be altered in its nature, is not in its solubility, and a simple washing in warm water is sufficient to

The discovery of this singular fact, which established photo-lithography, is certainly one of the most remarkable made by Poitevin, but this clever experimentalist did not rest content at this point. He soon discovered that his gelatinous bichromate of potash coating loses its properties of swelling when it has been submitted to the action of light. The impressioned film, treated with water, under special conditions swells slightly in the parts which the light has not acted on; while it remains unaltered in those parts where the light has acted. Here then was a

remove from the stone the greater part of the unaltered matter which has been unable to penetrate it. But if the surface thus prepared is exposed to the action of light through the unequally transparent parts of a negative, a change takes place which is certainly not an ordinary coagulation, and to which the oxidation of the chromic acid doubtless contributes, by rendering the albumen insoluble, and causing it to remain on the stone in quantities the larger the more intense the exposure to the light has been. Thus changed, the albumen resists water as if it were a greasy or fatty substance. In this state it readily absorbs an ordinary greasy ink, which does not adhere to the portions of the stone where the light has not acted, so that, if a roller charged with an ink containing soap, which lithographers call transfer or re-printing ink, is passed over the stone the ink adheres only to the albumenised parts of the surface, and the latter is thus coated with a greasy ink distributed in varying proportions of an ordinary drawing. The excess of ink is removed by acidulation and damping with a sponge. The drawing is made level by being submitted to the ordinary lithographic operations, that is to say, the removing of the colour with essence of volatile oil and the re-inking with the roller; and nothing further remains but to cover the stone thus prepared with a coating of gum which only adheres where there is no ink, and to submit it to ordinary inking and to acidulation, to be enabled to obtain from it as many copies as if the drawing, which has been entirely made by the light, had been made in the ordinary lithographic manner. Such is M. Poitevin's method.'

substance which offered an unequal surface, the reliefs and depressions of which corresponded to the lights and shades of the photograph; there was therefore nothing to hinder an electrotype being cast in copper from it, and the result would be an engraved plate capable of being printed from in the usual way. It is hardly necessary to say that we give here only the principle of Poitevin's process, which, in practice, requires extreme care. This principle was essentially ingenious, and capable of giving results which, if not perfect, were at least satisfactory. Poitevin must be regarded as the founder of modern heliography, his work being the germ of almost all the mechanical printing processes now known.

Photo-lithography has long been used with advantage; we shall see that it was the basis of photoglypty, the actual results of which are so remarkable. It gained for its inventor the celebrated grand prize founded by M. le Duc de Luynes.

Since 1857, M. Lemercier, an artist and *savant* of great merit, has utilised M. Poitevin's processes with excellent results; and Poitevin himself has also produced some beautiful collections, among which we may mention an album of forty-five terracottas, photographed in the galleries of the Viscount de Janzé, a photographic

reproduction of the engraved stones of the Egyptian museum of the Louvre; and in the galleries containing the most remarkable products of our national industry in the Museum of Art and Industry, may be seen a beautiful photo-lithographic stone.

The Processes of Baldus, Garnier and Salmon. In measure as we get nearer to our own time we find progress became more rapid. In 1854 M. Baldus produced proofs of photographic engraving which justly excited public admiration. M. Louis Figuier thus describes this process :—

'A coating of bitumen of Judea is spread on a copper plate. On the plate thus prepared with the impressionable resin is placed a photographic proof of the object to be engraved on transparent paper. This proof is a positive, and must in consequence produce, by the action of the light, a negative on the metal. About a quarter of an hour's exposure suffices to imprint the object on the resin, though it is not visible. It is developed by washing the plate with a solvent which clears away the parts unaffected by the light, and leaves a negative picture formed by the parts of the bitumen rendered soluble by the solar rays.

'But this picture is formed of a film so delicate and fine that it soon begins to partly disappear from the effects of

immersion in the liquid. To give it the necessary solidity and resisting power, it is left for two days to the action of diffused light. After the picture has been thus consolidated, the metal plate is plunged into an electrotyping bath of sulphate of copper, and now comes the most wonderful part of this process. Attach the plate to the negative pole of the battery, and on all the parts of the metal unprotected by the bitumen a coating of copper in relief will be deposited; attach it to the positive pole, and the parts which are unprotected will be attacked and hollowed, or, technically speaking, bitten out. Thus can one obtain at will from the negative pole an engraved plate, which can be used for printing from like a wood engraving, and from the positive pole a plate as used in copper-plate printing.'[1]

Since this time, M. Baldus has quite dispensed with electrotypy. A few minutes suffice him to make the plates fit for the copper-plate engraving process.

It is by means of a chromic salt without using the bitumen of Judea, that M. Baldus sensitises the copper plate. On a plate thus sensitised is placed the glass negative or positive which is to be reproduced, and the whole is exposed to the action of the light.

[1] It will be seen that this process is very similar to the electrotyping method of Poitevin.

After exposure the plate is placed in a solution of perchloride of iron, which attacks it in all the parts where the salt has not been acted upon by the light; a first relief is thus obtained.

As this first relief is not sufficient, it is augmented by replacing the plate in the perchloride of iron solution, after having passed over it a printing-ink roller. The ink attaches itself to the parts of the plate in relief, and protects them from the action of the mordant. By repeating this treatment the lines of the picture may be deepened to the required extent.

If a photographic negative is employed, a plate is produced for use as in the copper-plate process; if a positive, then the lines formed are in relief, and the plate can be used for typographic printing.

A little later on, in 1855, a new and extremely ingenious process was brought out by MM. Garnier and Salmon, of which the following is a description:—

'A brass plate is exposed, in the dark, to vapours of iodine, then submitted to the action of light behind a negative, and rubbed with a cotton polisher soaked in mercury, which only attacks the parts unaltered by the light. An inking roller being now passed over this plate the ink is repelled by the parts where the mercury has acted, and adheres in the free parts. The latter there-

fore, form the shadows, and when treated with nitrate of silver give a plate capable of use as in copper-plate printing. But if the ink is not removed, and, after the first corrosion with the nitrate of silver, a coat of galvanised iron deposited on the plate, the iron adheres only to the parts where the mercury acted, and the ink being now removed leaves bare the iodised brass. Mercury is again applied to the plate, and does not adhere to the iron. Passed under the inking roller the ink only adheres to the iron. If a typographic plate is required, instead of iron, gold is used to form the deposit, and the parts unprotected by the latter are *bitten* with an acid to the required depth.'[1]

By an analogous process M. Garnier obtained heliographic engravings made from negatives of views of monuments, landscapes, &c., of very remarkable quality. This operator received the grand prize for photography at the Exhibition.

In the last few years the processes which we have been describing have undergone many most important improvements. We shall glance at the methods as actually used by some celebrated operators.

Albertype.—M. Albert is a photographer of Munich.

[1] Traité general de Photographie, par Monckhoven, sixième édition. G. Masson. 1875.

well known from his remarkable works; his name has with justice been given to some photo-lithographic processes based on Poitevin's method. Heliographic engravings for the production of portrait-cartes are daily made in M. Albert's studios at Munich, and 200 engravings can be easily furnished from a plate in 12 hours.

A thick glass well polished is covered on its polished side when placed in a horizontal position with a solution of gelatine and bichromate of ammonium and albumen previously heated. This first slight coating is exposed to the light to render it insoluble in water. When this operation, which requires great delicacy and care, is finished, the first coating of gelatine is covered with another of gelatine isinglass, bichromate of potash, and a mixture of resinous matters (benzoin, tolu) in alcohol. When dry, the plate thus prepared is placed in a printing frame under the negative to be reproduced. When the exposure has been sufficiently long, the plate is plunged into tepid water, which dissolves the soluble parts unaltered by the light, and leaves slightly in relief the parts where the light has acted. This operation finished, the plate, when dried and rubbed with an oiled flannel, is ready for inking, which is done with an inking roller in the lithographic press; and 'this,' says M. Monckhoven, who has seen the clever experimentalist at work, 'is the

most delicate and difficult part of the process, and requires a clever workman to do it well. If the ink is sticky or pasty it is removed with turpentine and a sponge. The plate must be placed with care on to a sheet of india-rubber or a coating of plaster, with papers superposed, &c. The greasy ink with which the rollers are coated should be of superior quality. Purple is often added to it to give the proof the same appearance as photographic proof, and those obtained by M. Albert, in point of exactitude, delicacy, and tone, leave nothing to be desired.'

Obernetter's Process.—In this process, which gives very good results, and is very successful in Germany, the gelatine coating, exposed behind a negative, is covered with an impalpable, metallic, zinc powder. The plate, after this operation, is heated to a temperature of 200° centigrade. It is submitted to the action of a very weak solution of hydrochloric acid, and then well washed The parts of the gelatine covered with the metallic powder can be more or less damped and therefore refuse the greasy ink, whilst those free from the zinc receive it.

Modern Heliography.—There is a considerable number of methods of photo-engraving. At Paris some operators have arrived at very satisfactory results, but the greater part of them have processes based on secret

operations, and minutiæ, analogous to Poitevin's methods. To show what may be done by these processes the reader is referred to the opposite engraving which has been printed with the text, and is a reproduction of a sketch by Gustave Doré, photographed and engraved by processes similar to those which are here described in this chapter.

We take it for granted the reader can distinguish the copper-plate engraving, which is formed by grooves in the metal, from the typographic plate, in which the lines forming the picture, instead of being sunk in, stand out in relief from the metal. Heliography thus furnishes, first, plates in which the lines forming the picture are hollow and must therefore be printed as by the copper-plate process, and cannot be used for printing with type; and secondly, the plate in relief, similar to a wood-cut, and very easily printed with type, as that has been done for our fig. 38. This last process of heliography is especially useful for illustrating scientific and other books. Photoglypty (Woodbury process), which we shall describe in the next chapter, admirable though it is, as yet only produces plates, which must be printed without text in a special press.

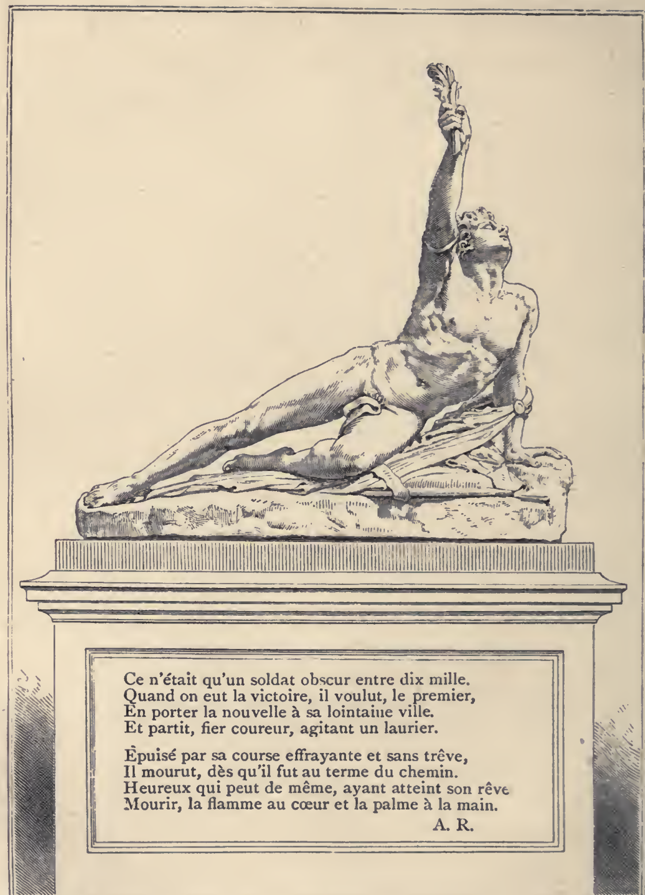
Amongst the most noted French operators we may mention M. Rousselon and Messrs. Dujardin Brothers.

Fig. 36

[Page 196

SPECIMEN OF A HELIOGRAPHIC ENGRAVING.

(After a Drawing by Gustave Doré.)



A PAQUIER DEL. CORTOT S. J. ROBERT SC.

FIG. 37

THE SOLDIER OF MARATHON.

The former gentleman manages Messrs. Goupil and Co.'s heliographic establishment, and has succeeded not only in copying old engravings, but in reproducing Nature. Landscapes, monuments, and even portraits are now made by heliographic processes. Messrs. Dujardin apply

Fig. 38.

THE SOLDIER OF MARATHON.
(Heliographic reduction of the opposite wood-engraving.

themselves principally to scientific, engineering, geographical, and cartographical reproductions, and the reproduction of old manuscripts. They produce by heliography steel plates, which have great merit, both from the number of copies they will furnish and the cheapness of

their production. These heliographic processes have already found numerous applications, nor will they be wanting in the future. They are used by *l'École des Chartes* for the reproduction of manuscripts,[1] by engineers and architects for reducing or enlarging their designs, by the Bank of Belgium and the Bank of France for the manufacture of notes.

To give an idea of the utility of the new methods for reducing or enlarging, we have reproduced on the preceding page an engraving on wood representing the Soldier of Marathon, and facing it is a reduction of it which has been made by heliography. (See figs. 37 and 38.)

[1] The photographic reproduction of manuscripts becomes daily of more importance; by its aid, texts which have become almost effaced, and which it is impossible for the eye to read, are made again legible.

CHAPTER II.

PHOTOGLYPTY. (THE WOODBURY PROCESS.)

WOODBURY—IMPRESSION OF A GELATINISED PLATE INTO A BLOCK OF METAL — WORKING OF PHOTOGLYPTIC METHODS IN PARIS—DESCRIPTION OF MESSRS. GOUPIL'S ESTABLISHMENT—M. LEMERCIER.

THANKS to the improvements of the English scientist Woodbury, the wonderful operations which we have just been describing have been greatly perfected. The importance of photoglypty, an art born but yesterday and hardly known to the public, has seemed so great to us that we have thought well to reserve it for a special description.

What principally excites admiration in this new process is that the proofs obtained by it are almost exactly similar to those produced by ordinary photographic processes; they have the same colour, the same appearance, and the same fineness of quality. Another almost inestimable advantage which this process offers is that the proofs may be multiplied indefinitely and very rapidly.

How is this prodigy performed? This is what we shall try and teach the reader, presuming in advance that he has already seen these photoglyptic pictures at the printsellers' and booksellers', and perhaps bought some of them, thinking that he was getting ordinary photographs. We were for a long time under a like delusion. Now that we are undeceived we think it useful and interesting to undeceive others, by thus describing an invention which is assuredly destined to a great future.

M. Goupil, the publisher, well known to the Parisian public, has acquired the right to work the Woodbury processes. He has organised a fine establishment at Asnières under the intelligent direction of M. Rousselon, who willingly initiated us into the mysteries of the new operations.

We shall describe faithfully what we have seen and admired. The first part of the method is based on the properties of bichromatised gelatine. A sheet of gelatine is prepared with a slight admixture of Indian ink, or other suitable colouring matter, and sensitised with an aqueous solution of bichromate of potash. This leaf of gelatine is placed in an ordinary printing frame, in contact with the negative exposed to light, and treated as in the printing and developing of an ordinary carbon proof.

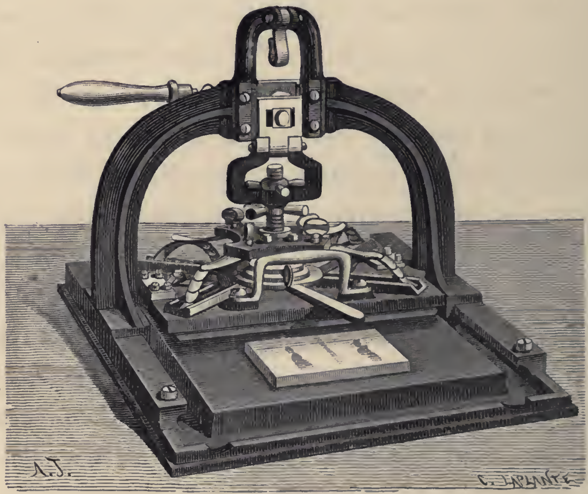
The latent image is registered in the gelatine in degrees of solubility or insolubility, just as in the carbon print, the degrees corresponding with every detail of the picture. The leaf is carefully removed from the printing frame in a dark room, placed on a glass plate covered with india-rubber varnish, and the whole is then placed for twenty-four hours in a receptacle containing tepid water constantly renewed in order to dissolve those portions of the gelatine which were protected from the action of the light, and thus render the leaf very much thinner. On being removed from its glass support, dried, and held up to the light, a faithful copy of the negative picture is seen; the lights are hollowed out and the shadows in relief. In one word, the photograph is reproduced in relief.

It will be seen that up to this point the process is very similar to Poitevin's, of which we have spoken in the previous chapter. But the miracle now commences. The gelatine leaf is next placed between a plate of perfectly level steel bound with iron, and a sheet of lead mixed with antimony. The gelatine film with its design in relief and engraving thus lies between two metal surfaces, the one of steel to serve as support, the other of lead much softer. In this position it is submitted to great hydraulic pressure, equal to

more than 700,000 lbs., and the leaf of gelatine, you will say, will be crushed to powder beneath such pressure.

Not at all; it acts like the die when striking out a coin or medal; although friable it is hard and unyielding,

Fig. 39.



PHOTOGLYPTIC PRESS.

harder than the lead into which it penetrates. In fact, on being taken from the press the lead is found to have received the exact impression of the gelatine leaf, and the astonished spectator sees every detail of the photograph reproduced in the metal, while the gelatine relief leaves the press quite uninjured and may be used again.

The lead plate is next placed in a special press (see fig. 39), and supplied with a semi-transparent ink formed of gelatine and Indian ink coloured with sepia; a sheet of paper is placed over this, the lever is pressed down;

Fig. 40.

TURN-TABLE REQUIRED FOR TAKING PHOTOGLYPTIC PROOFS.

and on being raised a few moments after, to anyone who has not seen the details of this astonishing process, the paper seems to have been converted into an ordinary photograph. The press once set going 10,000 facsimile prints can be obtained in a week.

The photoglyptic presses are placed on a *rotatory* table in such a way that the workman can keep them constantly supplied with the thick jelly-like ink. (Fig. 40.) The ink can be coloured to any shade, but sepia is the most generally used, as it gives the appearance of the photograph.

It is possible to use glass instead of paper for printing on. Photoglyptic proofs on being taken from the press are washed in an alum bath, which makes the print insoluble and so fixes it ; they are then dried, trimmed, and mounted on cardboard, and are now ready for sale. It is hardly necessary to say that in this description we have had to confine ourselves to giving our readers the principles of the photoglyptic process, without being able to enter into the detail of the delicate manipulations which require great skill on the part of the operator. It will be patent to everyone that the photographic negative from which the photoglyptic proofs are to be formed must be made under the best conditions of sharpness and clearness ; the lights and shades should be distinctly defined, so that the gelatine film receives the action of the light freely.

M. Goupil is not the only one who makes use of this processs. M. Lemercier has also organised a fine pho-

toglyptic studio, and copies have been printed to the extent of 5,500 by this clever artist.[1]

Photoglyphy is completely successful in the reproduction of portraits from nature, but it is especially suitable for reproducing pictures, engravings, &c., which are rendered with great delicacy. The new invention has already placed an innumerable quantity of prints in the

[1] In order to understand the principle of this beautiful process, the reader must bear in mind that the gelatine relief when subjected to pressure is first laid upon a perfectly flat and true plate of hard steel, the leaden plate is then placed upon the relief, and the whole pressed between the parallel jaws of the hydraulic engine. The direct result of the pressure is that the soft leaden plate has taken the true level surface of the steel, and the only divergence from this perfectly level surface is caused by the gelatine relief, which has impressed into the lead a complete intaglio picture in which the deepest shadows recede farthest from the level, while the high lights rise to the true level of the plate. The success of the process depends entirely upon the true level of the steel plate employed in the press. It will therefore be readily understood that in pulling the impressions the second press must also be supplied with a perfectly level plate of glass or steel. The intaglio slightly greased is placed in position and charged with a warm solution of semi-transparent ink, the paper placed in contact with the ink ; the level cover of the press is then brought down and locked. The superfluous material thus pressed out, the gelatinous ink sets in an instant, and the resulting proof is a pictorial relief in permanent ink ; the high lights have been pressed out, leaving the white paper exposed, and the semi-transparent ink rises in beautiful gradations through the delicate shades and half-tones, attaining its highest relief, and therefore its greatest opacity, in the deep shadows. But when the proof is thoroughly dry, it presents a flat surface which none but an expert could distinguish from an ordinary silver print, worked by the Woodbury Co. of London.

The Woodbury process, worked by the Woodbury Co. of London, is largely used for book illustration on account of the delicacy and beauty of its proofs. It has, however, one great defect in the eyes of publishers, and that is, that the proofs require to be cut and mounted.—Ed.

market, amongst which we may mention a great number of reproductions of pictures; some of the latter having been produced to the extent of 30,000 copies and more. Photography, years ago, would have been powerless to furnish so large a number. Thus these photographic processes will henceforth rank among the industries. A theatrical journal has recently made use of photography for reproducing each week the portraits of four most noted dramatic artists. The prints are pulled in the Lemercier presses and mounted on the journal itself on a space reserved for each.[1] This curious art must undoubtedly prove of most valuable assistance for illustrating books of fine art, travel, &c., by furnishing proofs which offer all the advantages of photography without its drawbacks.

It is hardly necessary to insist further on the importance of the new invention; it will be plain to everyone that it must be considered as the solution of a great problem destined to be an epoch in the history of invention. The only objection which can be raised to photoglypty is this: Are the gelatine prints permanent? Will they be as little affected by time as typographic prints? It is probable, for it is not easy to see how gelatine and Indian ink can alter; nevertheless, time alone can solve the question with certainty.

[1] There are several photo-illustrated periodicals in London.—Ed.

Another but less important objection might perhaps be taken to the somewhat uncouth name of the new discovery; but this name is very appropriate to the process, being derived from two Greek words—*photos*, light, and *gluptein*, to engrave—to the union of which one will soon get accustomed.

CHAPTER III.

PHOTOSCULPTURE.

AN UNEXPECTED DISCOVERY—PHOTOGRAPHY APPLIED TO SCULPTURE—WILLÈME'S PROCESS IN 1861—DESCRIPTION OF PHOTOSCULPTURE.

WE have just seen that photography has furnished the engraver with appliances as valuable as they were unexpected; but the art created by Daguerre can do yet more.

Not only does it engrave the copper plate as done by the hand of the artist, but it comes to the aid of the sculptor, and relieves him in his work.

In the course of the year 1861, the Parisian press announced that a well-known inventor had discovered the means of reproducing statues by photography, not merely to represent them in picture, which would have been nothing wonderful, but to make diminutive facsimiles of them. If an object, animate or inanimate, whether marble statue or living man or woman, were placed in the midst of M. Willème's (such was the name of the ingenious inventor) studio, a few days after a

little statue of clay would be modelled. It would be done by photography, and the statuary image would be the exact representation of the living model.

Such a result appeared incredible, and the public, accustomed to being hoaxed by the press, looked on it with great distrust. But facts must be believed; and as soon as the mystery was explained, it was seen that there was nothing fantastic or incomprehensible in Willème's process, and it was soon proved that work, perseverance, and ingenuity alone composed the miracle.

The new discovery was at once christened with the name of *photosculpture.* This curious art is designed, not to transform a photograph on paper into a sculptural relief, but by the aid of photographs to imitate in a certain way a statue or living person.

To explain the processes of photosculpture, we quote a passage from the *Annuaire Scientifique* for 1861, in which Willème's invention is described: 'A model is placed in the centre of a circular platform the circumference of which can be included in the field of a single camera, by which several photographs of the objec from different points of view are to be obtained. To simplify matters, suppose these photographs be restricted to four—first, A of the face, the 2nd B of the back, the

3rd C of the right profile, and 4th D of the left profile—of the object; these obtained, it is necessary to use them for reproducing the model in relief. To effect this the plaster or clay to be sculptured is placed on a level plate, the circumference of which is divided into as many equal parts as there are photographs to be taken, in this case, therefore, four. Two upright tablets are fastened vertically and at right angles to each other to the plate on which the plaster is placed. These tablets are made to slide to or from the plate, and are for the purpose of holding two of the photographs which must be those of views at right angles to each other, such as the front A, and the profile C. In order that the photographs may be exactly even, both they and the tablets are marked with a double system of horizontal and vertical lines, which greatly facilitate the placing in true position.

'The two points of a pantograph, an instrument for counter-drawing, are applied; the one to the photograph A, of which it follows all the outline, the other to the soft or hard mass on which it traces a silhouette, an exact copy of the silhouette of the photograph. Another pantograph at right angles to the first acts in a similar manner in reproducing the silhouette of the profile C. In the same way, the second points of the two other

pantographs, the first points of which are guided in the same way over the photographs B and D, reproduce on the block the silhouettes of the back and of the profile D. Simply with four operations the mass to be sculptured would be but very imperfectly manipulated; but nothing prevents that instead of four, eight, twelve, or twenty-four views should be taken . . . . in fact, the number sufficient for obtaining the requisite continuity of the exterior outlines so that there would be but an edge or two to correct by hand. In any case the number of the pictures must be one divisible by four; twenty-four is a very convenient and sufficient number.

'The photographs are numbered in order from one to twenty-four; the turning plate holding the clay to be modelled is also divided into twenty-four equal parts. The photographs on which the two pantographs act simultaneously are those taken at an angle of 90 degrees from each other, viz., one and seven, two and eight, three and nine, up to twenty-four and six, and each time the tablets receive fresh photos, the plate is turned one division.

'But this series of twenty-four operations will only give the exterior outlines, and the statue will be incomplete until such indentations as the nostrils, ears, &c.

have been brought out. These M. Willème obtains by following with the pantograph not only the profiles, but also the lines of light and shade which represent parts in depression and relief.'

In 1861, M. Willème constructed a photosculpture studio at the top of the Champs-Élysées. He has succeeded in reproducing some statues, and, not content with this, boldly attempted to produce the statue of a living person just as his portrait is taken in a photographic studio.

For some time past Messrs. Giroux have exhibited some of these curious productions; amongst others diminutive figures of the Duke de la Rochefoucauld and Madame Galiffet may be seen; but exact as are the copies of these personages, from an art point of view, they present nothing more than common and mediocre statues. How can a gentleman in a double-breasted coat, or a lady fortified with crinolines, compete with the Apollo Belvidere, or the Venus de Medicis? nudity is imperiously exacted by the art of Praxiteles. In spite of his attempts M. Willème failed, but he has none the less created a new application of photography worthy in all respects to be noted and taken up by some bold spirit.

Though, from an art point of view, sculpture after

nature by photography seems impossible, there is reason to hope that the first attempts of M. Willème will be one day perfected, and that his process may then be employed in reproducing, with precision and exactitude, the works of old and modern masters.

CHAPTER IV.

PHOTOGRAPHIC ENAMELS.

VITRIFICATION OF A PHOTOGRAPH—CAMARSAC'S PROCESS—JEWELLERY ENAMEL—METHOD OF MAKING—POITEVIN'S METHOD—PERMANENT GLAZE PHOTOGRAPHS.

WE have seen that the image of the camera can be fixed on paper, on metals, and on glass.[1] It can also be so burnt into porcelain by a certain process that once annealed it is as indelible as ceramic painting, and resists time and all other deteriorating agents. Many manufacturers have employed photography for decorating porcelain vases; and some of these productions are really works of art and good taste.

M. Lafon de Camarsac was the first who conceived the idea of employing photography in this curious and unexpected manner. It occurred to him that it might be possible to transfer to porcelain a positive image

[1] Transferred direct to the surface of a block, it dispenses with the work of the artist on wood, affording the engraver an exact and delicate guide for his graving tool.

formed of substances vitrifiable by fire, to submit this to a high temperature, and thus to obtain an enamel which reproduced the original photographic design. With this object in view the inventor set patiently to work, and in 1854 photographic enamels were invented.

To transform the heliograph into an indelible painting, Camarsac made a sensitive coating capable of receiving the impression from a glass photograph without adhering to the latter. After exposure to light the picture is formed clear and distinct. The inventor now substituted ceramic colours for the parts which should be destroyed by the action of heat.

By means of a fine sieve the inventor deposited the metallic oxide colours delicately on the surface of the coating; he spread these powders either with a brush or by imparting a rapid movement to the plate. In proportion as the powder is spread over the coating, the heat should be gradually increased. The enamel powders follow most delicately all the features of the drawing, which they partly penetrate, and the vigour and delicacy of which they faithfully render. After cooling, the proof must be dusted to remove any particles of colour which may adhere to the whites of the picture.

The piece is now ready for the *burning-in* process which is done in the same way as usual in ceramic-paste

colouring, a more or less hot fire being employed according to the nature of the colours to be produced.

The fire destroys the organic substances, and fixes the picture formed by the indestructible colours as soon as they are vitrified.

'One of the remarkable properties of these pictures,' says Camarsac, 'is the appearance of fine enamel which they present, and which no other painting could furnish with a like degree of delicacy. This circumstance proves fully that the powder enamel has taken exactly the place of the organic matter, and it must be seen that this appearance is due to the remarkable delicacy of the photographic deposit, which is formed in degradations of thickness inappreciable to the eye . . . . There is no colour which cannot be applied to the heliographic surface; gold and silver are as easily used as blue or purple.' [1]

It will be seen that the inventor of photographic enamels describes his process with great reserve, wishing doubtless to keep it secret. But we are now acquainted with Poitevin's method, the details of which we will briefly describe.

To produce a portrait on enamel for mounting, as they are often done, in a brooch (fig. 41), a pin, &c., a

[1] Lafon de Camarsac's Patents, 1874.

positive on glass is first made of the object to be represented.

This positive is applied to a glass coated with a sensitised surface formed of a mixture of gum and bichromate of potash. The light traverses the transparent parts of the positive, and acts on the bichromate of potash in a manner which, though invisible to the naked eye, modifies it in such a way as to give only to those parts the curious property of retaining the charcoal dust or powder. As soon as the exposure to the light is finished, the bichromatised plate is removed, and, though appearing totally unaltered to the eye, if a fine charcoal dust is sprinkled over it by means of a sieve (fig. 42), the charcoal only adheres to the parts where the light has acted and nowhere else. Thus this fine charcoal shower brings to view, as if by enchantment, a portrait both delicate and faithful, in which the distinctions of light and shade are well preserved.

Fig. 41.

PHOTO-ENAMEL BROOCH.

The photographic proof is thus developed, a coating

of charcoal showing the design; but this coating is not permanent. By means of a brush a coat of collodion (*normal*) is spread over it, which soon dries.

The next operation is one requiring very great dexterity of hand. The fine coating of collodion has to be

Fig. 42.

DUSTING SIEVE.

separated by the aid of pointed instruments from the glass plate, and brings away with it the charcoal proof. The film of collodion is then placed on the convex plate formed of white enamelled copper; a fixing paste similar to that used by ceramic painters is spread over the enamel with a brush, and the fixing agent becomes incorporated

with the carbonised parts of the proof, of which it retains the image or design.

When subjected to a red heat in an enamelling furnace the fixing paste adheres to the charcoal powder, vitrification takes place, and all the organic matters are destroyed; and the vitrified carbon alone is fixed in an indelible manner.

If a coloured proof is required, the design in black is traced over by an artist with colouring pastes used for decorating ceramics, not always, of course, without some slight damage to the beauty of outline and tone of the photograph.

Messrs. Desroche, Henderson, Lochard, Gongenheim, Forest, Berthand, and others, are justly celebrated for their photographic enamels, which are much used in jewellery, and we have seen portraits made by this last artist which have the quality of ancient miniatures, with the lifelike resemblance which photography alone can assure.

Similar processes have been used by some operators to obtain the vitreous or glazed photographs of which some remarkable specimens were exhibited at the Exhibition of 1867.

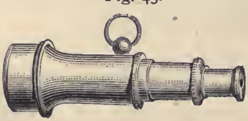
CHAPTER V.

PHOTOMICROGRAPHY.

THE TOY MICROSCOPES OF THE PARIS INTERNATIONAL EXHIBITIONS—450 DEPUTIES IN THE SPACE OF A PIN'S HEAD—ARRANGEMENTS OF PHOTOMICROGRAPHIC APPARATUS — THE NATURAL SCIENCES AND PHOTOMICROGRAPHY—RESOURCES BORROWED FROM THE HELIOGRAPH.

THE reader who may have visited the International Exhibitions in Paris in the years 1859 and 1867 cannot have forgotten the wonderful productions of microscopic photography which appeared there. At the Palace of Industry thousands of objects were sold, giving some idea of the minuteness to which photographic prints could attain.

Fig. 43.



TOY MICROSCOPE OF THE EXHIBITION OF 1867.

There were small microscopes (fig. 43) containing photographs the surface of which did not exceed the size of the head of a pin, where were to be seen through a magnifying glass the portraits of the 450 deputies of the Empire.

Photography succeeds in taking the impression of a diminished image, but it is also capable of rendering permanent the images magnified by the microscope. Before studying Lilliputian photographs we shall pass in review those which able operators now obtain from images enlarged by the microscope. We shall examine the results of the process called photomicrography.

Photomicrography has rendered and still renders every day the greatest services to the Natural Sciences. Microscopic study is fatiguing, and the eye cannot observe for long an object through the magnifying glasses of this instrument without feeling wearied. Thanks to photomicrography, the naturalist can have in his hands prints representing under a considerable enlargement the infusoria, grains of pollen, and the most delicate organs of vegetables or animals. On this account this art, the birth of yesterday, must already be considered as a valuable assistant to scientific investigation.

We shall chiefly examine microscopic photography in relation to its application to the natural sciences. We shall do so by the aid of a distinguished amateur, as skilful a photographer as he is a good microscopist, M. Jules Girard, who has kindly authorised us to make extracts from his interesting works.

The arrangement of a photomicrographic apparatus

requires peculiar care. 'However well arranged a camera may be,' says M. Girard, 'it is indispensable that it should satisfy numerous conditions in ordinary photography, which it is more rational to avoid in photomicrography by simplifying and reducing the number of its parts. In adapting a microscope to the end of a camera such as every photographer possesses, there is no need of any particular arrangement, because any one of these instruments, of whatever kind it may be, is suitable for the production of a picture. Let it be a bellows camera which will draw out to about a yard, and of such dimensions as will take in a glass plate of 8 × 10 inches; this size will be more than sufficient. The shape of the glass plates usually sold, which are longer than they are broad, is not very suitable to receive an image which, being circular, is always inscribed in a square, when the whole field of projection is made use of: the circle is also more characteristic of microscopic impressions.'

In order not to change anything in the arrangement of the camera there must be a plate-holder or series of plate-holders, which fit one within the other, and also fitting the slide which is used in ordinary photography. The glass plates must also be specially cut in squares of two or three sizes. The sensitive surface is thus more cleanly and regularly covered, and there will be also

more economy in the use of the chemicals. With certain glass plates, such as those used for the stereoscope, it would be advantageous to employ a double slide giving two impressions at the same time.

The front of the camera is usually made moveable, so that lenses of various sizes can be used.

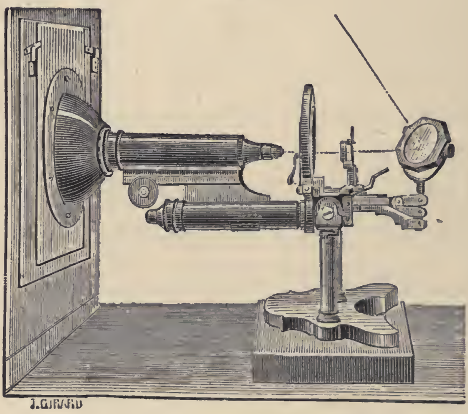
The ordinary lens-holder being removed from the front of the camera, there should be fixed over the aperture, in such a manner as to prevent any light being admitted at the junction, a truncated cone of india-rubber, strong black cloth, or other perfectly opaque flexible material, the tube of the microscope being inserted into the narrow end of the cone.

It is absolutely necessary that the junction should be made by a simple contrivance in order to give flexibility to every movement. A mere opening in the flange allowing the tube of the microscope to be inserted into the camera would make the combination too rigid, for the two instruments must be so united as to preserve to each a perfectly independent motion (fig. 44), so that that of the one may not interfere with that of the other. The microscope is thus withdrawn from the inevitable shakes given to the camera; in regulating the focus, or in withdrawing, even with all possible precaution, the dark slide containing the sensitised glass

plate, the slightest shake would cause a disturbance of the position of the image.[1]

As an ordinary camera cannot generally be sufficiently

Fig. 44



MICROSCOPE FITTED TO THE CAMERA.

drawn out, there may be fixed to the flange a metallic or wooden cone, to the other end of which is fastened the india-rubber or black cloth junction.

[1] This independent action of the camera and microscope containing the object-glass, confers a decided advantage in the hands of a skilled operator. But the amateur would probably be safer in using the microscope, cone, and camera rigidly united, as it is of great importance to obtain a direct light thrown from the mirror of the microscope through the axis of the instruments; and, moreover, the stage of the microscope which carries the object to be photographed and the prepared plate ought to be perfectly parallel to each other.—ED.

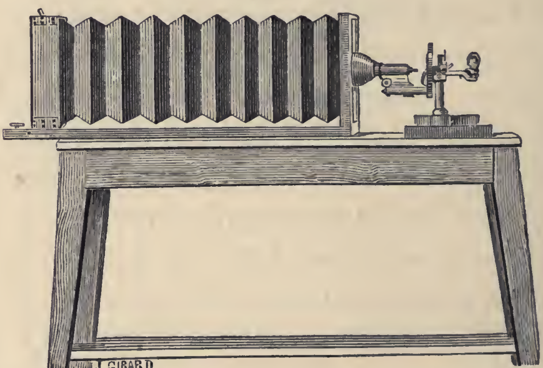
In place of the ordinary camera a simple oblong box provided with a slide may be used, but then the focal distance would be invariably the same. Though an ordinary microscope may be used, it will be found better to have the tube made as short as the mechanism will admit of, as a tube of the usual length would prevent the expansion of the pencil of light thrown upon the sensitive plate. The interior should be coated with a dull black, or still better with very fine black velvet, in order to avoid any reflections from a polished surface.

The microscope should be attached to a heavy metal stand so as to make it as steady as possible. The height of the support should be such that the optical axis of the microscope is exactly in a line with the centre of the ground-glass back of the camera. The apparatus could then be put on an ordinary table very firmly placed; but the height of ordinary tables is not adapted to the convenience of the operator, and want of sufficient height is a cause of constraint and fatigue. The best manner, in our opinion, to place it in a position suitable to work at one's ease is to let it rest on a bench, of the breadth of the camera and about a yard and a half long, mounted on solid legs having an outward inclination to give it more firmness (fig. 45). In order to compensate for the

inequalities which are often found in flooring, it would be well to furnish it with levelling screws.

Near the bottom of the legs another board might be fixed, which would increase their firmness and also be very convenient for placing any small articles upon while working, should there be no other table at hand. The height would be regulated, so that when standing, the centre of the ground glass would be on a level with

Fig. 45.



ARRANGEMENT OF THE PHOTOMICROGRAPHIC APPARATUS ON A BENCH.

the eyes. To stand upright is perhaps a little more fatiguing than to make the trials of focussing seated on the edge of a lower table, but, by standing, one gains considerably in ease and quickness of movement.[1] In

[1] The bench ought to be made long enough to support the camera when fully expanded.—Ed.

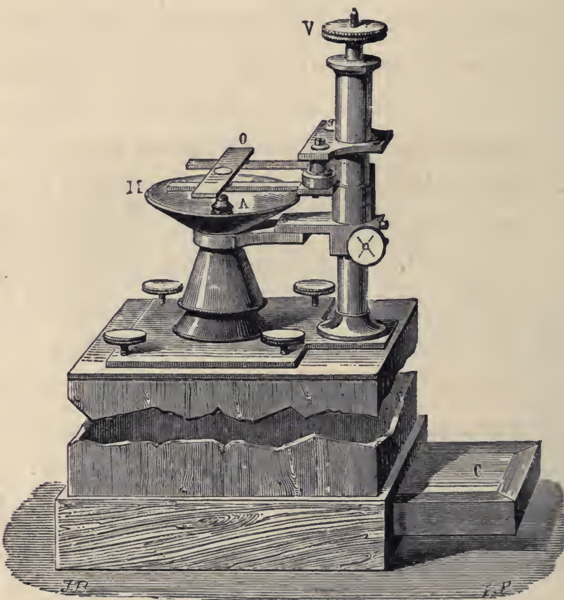
case the camera, when expanded, should be much longer than the bench which supports it, it would be necessary to add metal brackets, or in some other way support the extreme end of the camera to prevent any rocking motion when the movable back is inserted or taken out.

As this apparatus does not admit of the focussing of the image so readily as in the ordinary photographic camera, a bench like the one described—which may be readily moved to suit the light— will prove of great service. By not having the camera too much expanded the awkwardness of stretching the arm to reach the focussing screw, when the head is under the focussing cloth, is avoided. In case of need recourse might be had to an assistant who would turn the screw according to directions given. Wishing to avoid this inconvenience, M. de Brebisson has made use of a mirror placed at the bottom of the camera. The operator then leans over the apparatus placed upon a table of suitable height, the head under the focussing cloth, and the hand free to hold the screw. A system of screws and connecting rods has also been devised ; but a position even a little inconvenient to which one soon gets accustomed is preferable to having recourse to pieces of mechanism which act at a distance, and for that reason are often defective. The sensitiveness of a micrographic screw does not suit such ar-

rangements well, for, however correct their action may be, it can never equal the free and direct motion of the hand.

The microscope may also be placed vertically, as represented by fig. 46.

Fig. 46.

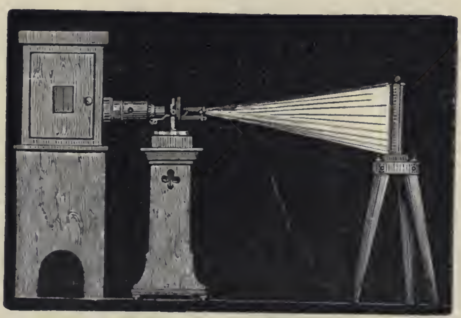


VERTICAL MICROSCOPE ADAPTED TO THE CAMERA FOR PHOTOMICROGRAPHY.

V is the focussing screw. O represents the slide which carries the object to be magnified, placed above the object-glass A. But the arrangement we have previously described is to be preferred.

The photomicrographic apparatus being properly placed, it is necessary to give every possible attention to lighting the object effectually. This is of very great importance in such operations. Under certain conditions the light of the sun may be replaced by an artificial light produced by the combustion of magnesium or the electro-magnetic light, or oxy-hydrogen light as in fig. 47.

Fig. 47.

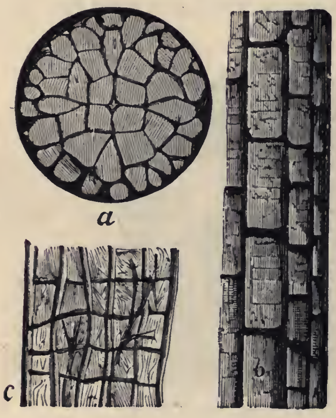


PHOTOMICROGRAPHIC APPARATUS FOR ARTIFICIAL LIGHT.

We shall not enter into matters of practical detail analogous to those we have described in the Second Part of this work ; we shall confine ourselves to speaking of the results due to this branch of the photographic art. The tissues of plants, insects, the marvels of the invisible world, which fatigue the eye when examining them through the microscope, are fixed on the collodion with a precision unknown to the most scrupulous draughtsman.

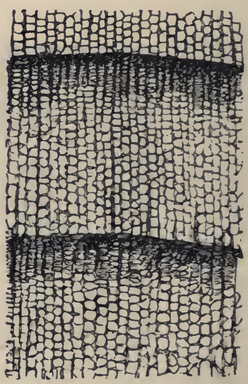
Fig. 48 gives the portrait of a flea photographed after being enlarged by a miscroscopic object-glass. The engraving has been done in such a manner as to reproduce faithfully the photograph, which was taken by the processes described in this chapter.

Fig. 49.



FACSIMILE OF THE PHOTOGRAPH OF SECTIONS OF THE STEM OF A CANE.

Fig. 50.



SECTION OF THE WOOD OF A FIR-TREE.

Fig. 49 is the reproduction of a photograph of thin sections of a cane. At *a* is seen the transverse section of the stem, and at *b* the longitudinal section. Beside it we place the section of a piece of fir represented in the same manner (fig. 50).

By uniting the processes of heliography and photomicrography, the photograph obtained directly from the

FIG. 48

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FAC-SIMILE OF THE PHOTOGRAPH OF A FLEA, OBTAINED BY THE PHOTOMICROGRAPHIC APPARATUS.

magnified object has been converted into a heliographic plate.

Fig. 51 is printed from a heliographic plate which

Fig. 51.

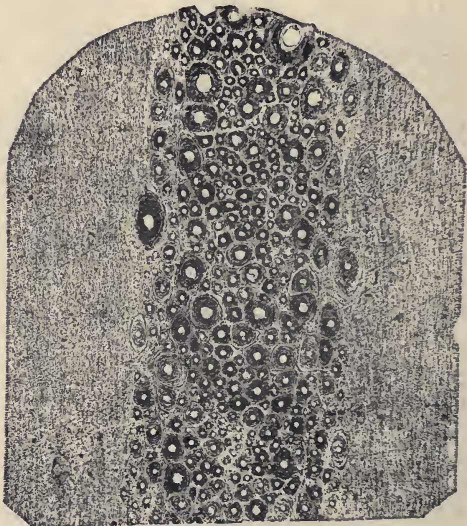
Héliogravure DURAND.

GROUP OF DIATOMS.

was taken from a photograph of diatomaceæ representing these infinitely small objects magnified 450 diameters. This engraving is the mathematically exact copy of the

image given by the microscope. These astonishing organisms, which are met with in incalculable numbers on the surface of sea-weeds or pebbles which have been exposed to the action of mineral water, and which in

Fig. 52.



Héliogravure DURAND.

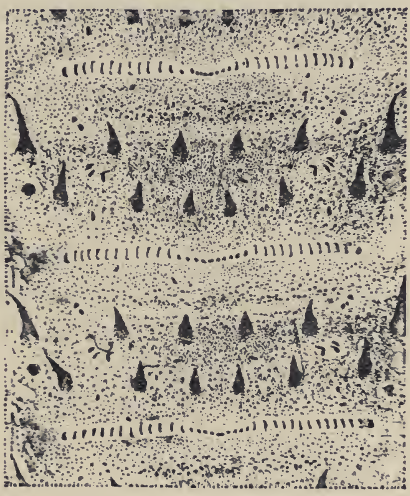
SECTION OF THE FIN OF A WHALE.

reality are smaller than the smallest prick given by the finest needle, are here figured by the heliograph just as Nature has created them.

Photography has fixed their images magnified by the microscope on collodion; it has then formed the en-

graved plate, and enabled us to insert it in this book. This plate was produced by heliography from a very fine photomicroscopic negative by M. Jules Girard. The other two designs (figs. 52 and 53) were produced in the same manner.

Fig. 53.



EPIDERMIS OF A CATERPILLAR.

The first (fig. 52) represents the section of the fin of a whale.

And the second (fig. 53) the epidermis of a caterpillar.

We think these examples are sufficient to prove the

immense resources which the Natural Sciences may find in the processes of photomicrography. But if the operator is now able to fix the image of an almost imperceptible object magnified by the microscope, he can also, as we shall see, perform the inverse operation ; that is to say, he can photograph the image of an object reduced to Lilliputian dimensions. The toy microscopes, which we have already mentioned, afforded a trifling specimen of this last application of an art which subsequently produced the photographic despatches of the siege of Paris.

CHAPTER VI.

MICROSCOPIC DESPATCHES DURING THE SIEGE OF PARIS.

APPLICATION OF MICROSCOPIC PHOTOGRAPHY TO THE ART OF WAR—THREE MILLION PRINTED LETTERS OF THE ALPHABET ON THE TAIL OF A PIGEON—ENLARGEMENT OF THE DESPATCHES—THEIR CONVEYANCE BY CARRIER-PIGEONS.

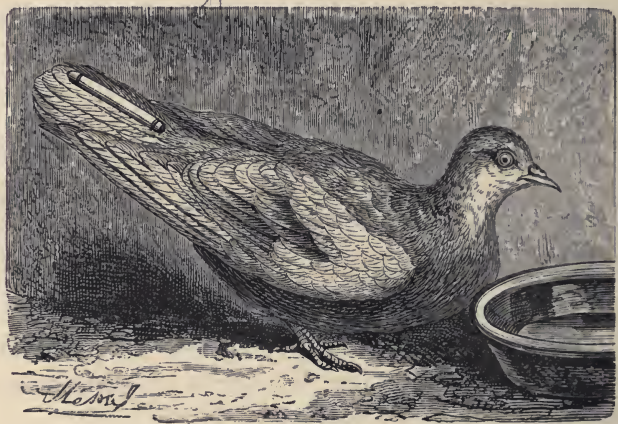
DURING the war of 1870–71, when Paris was invested by the enemy, photography succeeded in reducing the size of the messages sent by carrier-pigeons, so as to render them almost invisible to the naked eye. No philosopher could have imagined this use of photography, called forth by the dire necessities of war.

No one can have forgotten the service rendered by balloons during the siege of Paris, nor the wonderful part played by carrier-pigeons, which brought to the besieged city news from the outer world. But these birds, however strong they might be, could only carry with them very light burdens through the air. A thin sheet of paper two or three inches square was all the load that could be entrusted to these winged messengers. But

how write orders, send despatches, give precise instructions in such a minute letter? the most able caligrapher could hardly make it contain the letters in a single page of a printed volume.

Microscopic photography came to the assistance of

Fig. 54.



CARRIER-PIGEON WITH PHOTOGRAPHIC DESPATCHES.

the besieged; it solved the difficulty as no other art could have done; it reproduced on a film of collodion weighing less than a grain, more than three thousand despatches, that is to say, the amount of sixteen pages of folio printed matter.

We shall recall briefly these memorials of microscopic photography utilised by the aid of carrier-pigeons.

At Tours, all public or private despatches were printed on a large sheet of paper, which could contain about 300,000 letters. M. Dagron, who left Paris in a balloon, reduced this big poster to a small negative scarcely one quarter the size of a playing card.

These were at first printed on a thin sheet of paper,

Fig. 55.

QUILL CONTAINING MICROSCOPIC DESPATCHES FASTENED TO A TAIL-FEATHER OF CARRIER-PIGEON.

but afterwards on a film of collodion, which, though weighing less than one grain, contained the matter of several newspapers.

Several of these films representing a considerable number of despatches were rolled up and enclosed in a quill about the size of a tooth-pick. This light and novel letter-box was attached to the tail of the pigeon as represented in figs. 54 and 55. The bird-messenger only carried this light burden. Care was taken on his arrival and at his departure to put a stamp on his wing to prove

the date of the receipt, or despatch of the messages (fig. 56).

A very considerable number of printed pages were reproduced by the processes of M. Dagron and his assistant, M. Férnique. Each page contained about 5,000 letters, say about 300 despatches. Sixteen of these pages

Fig, 56.

STAMPS, SHOWING WHEN DESPATCHES WERE FORWARDED OR RECEIVED, PRINTED ON THE WING.

were contained on a film about two inches long and one inch broad, and weighing less than one grain. We have endeavoured to give the exact appearance of one of these despatches in our figure 57. The reduction was made to the eight-hundredth part of the size of the original. Each pigeon could carry twenty of these films in a quill, the whole not weighing more than fifteen grains. These despatches united could easily form a total of two to three

millions of letters—that is to say, the matter of ten such volumes as this.

To produce these very minute specimens of photography, recourse was had to the process already utilised before the war in the construction of the little photographic toy microscopes, and of which the following is a description. The albumen process was used, which gives the greatest possible delicacy to the negative image. This small image, further reduced by the aid of lenses, is reproduced in the focus of a camera, and fixed on a plate of collodionised glass, on which several microscopic photographs are received at the same time. This plate will be a positive; the plate from which it was produced being a negative. It is then cut into small fragments each containing a picture. M. Dagron fixed his little microscopic photographs in 1867 into various articles, such as the toy microscopes already spoken of, into rings, penholders, &c.

Fig. 57.

FACSIMILE OF A MICROSCOPIC DESPATCH DURING THE SIEGE OF PARIS.

One of the practical difficulties at this time was the

magnifying the little glass plates sufficiently. M. Dagron succeeded in doing so by employing the Stanhope lens.[1]

It is a miniature microscope with considerable magnifying powers. The image seen through it is magnified about three hundred times.[2]

[1] The lens used for toy microphotographs resembles the Stanhope lens, but is not cut down in the centre to form a diaphragm. It consists simply of a cylinder of flint glass, or long plano-convex lens whose focus is its own plain surface, to which the photograph is attached with Canada balsam.

[2] As the author has given a full description of one of the most interesting and important applications of microphotography, I venture to append a brief supplementary account of my personal experience in the production of minute photographs.

It is now nearly seventeen years since—after a series of experiments which extended over twelve months—I found out a method by which the finest results could be readily obtained. The instrument used was a long camera set up in an inclined position, in a dark room, with its upper end projecting through an aperture in the window so as to command a clear northern light. The negative to be copied was placed in a frame at the end of the camera. While the lower extremity of the camera supported the object-glass of a microscope fixed in a sliding tube supplied with a coarse and fine adjustment, a glass stage with spring clamp was also added for the support of the collodionised plate. Above the stage there was placed an ordinary microscope set so as to correspond with the optical axis of the instrument.

The first great difficulty to be overcome was focussing. To use any ordinary semi-opaque focussing screen would have been labour thrown away, as the image to be formed was not larger than a pin's head; I therefore adapted a microscopic glass slip, and first brought the specks of dust on the inner side of the glass into the focus of the microscope; it was then necessary to focus the image cast by the object-glass on the same dusty plane. This method, however, turned out to be useless. As I was very young and inexperienced at the time, I was completely puzzled until I discovered that the refraction of the glass slip prevented me

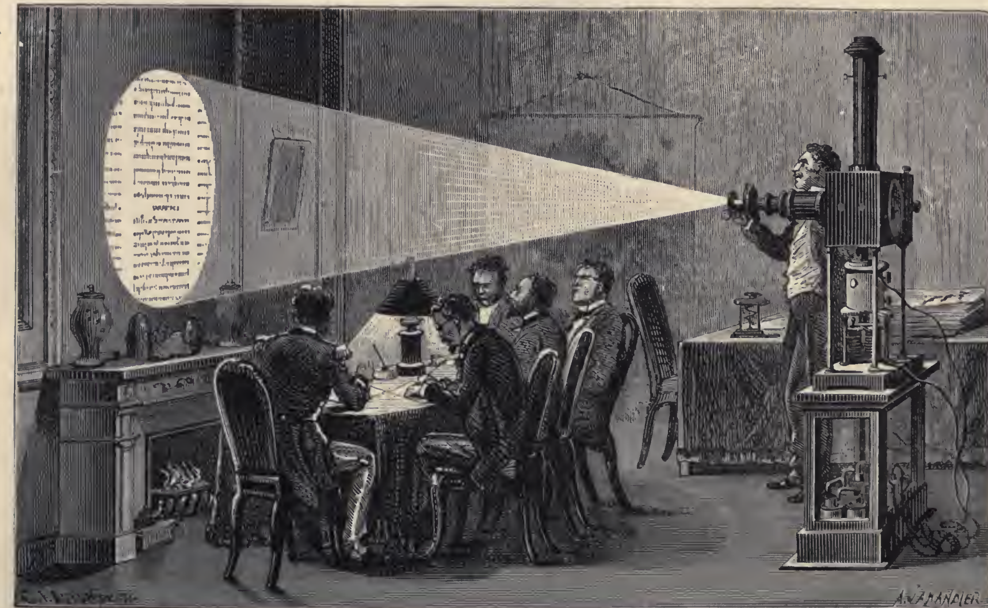


FIG. 58

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ENLARGING MICROSCOPICAL DESPATCHES DURING THE SIEGE OF PARIS.

The production of microscopic prints requires great ability on the part of the operator, and great delicacy in the various manipulations.

from finding the actual focus. The focussing slip was at length thrown aside, and I determined to focus the tiny image in air without a screen, but with the silken hair from a spider's web stretched across the field on the glass rim of the stage, and on the same plane as that to be occupied by the sensitive plate. It was then necessary to focus the microscope to the silken thread, and afterwards to bring the tiny image to the corresponding plane. This, I need hardly say, proved absolutely satisfactory, and, moreover, when the focus had been once determined, it remained unaltered for an indefinite length of time. The ultimate success of micro-photography (with collodion) depends, greatly, on the accuracy of focussing, as the 1,000th part of an inch of variation in the position of the object-glass throws the instrument out of adjustment. One object in using a glass stage and glass supports was to do away with the alteration of focus caused by the expansion and contraction of brass or other metal.

The mode of operating which I followed in taking the photograph was nearly identical with that of taking an ordinary wet collodion positive, with one or two modifications very simple in themselves, but at first extremely difficult to find out. By using an ordinary collodion and an iron developer, the resulting picture, when placed under the microscope, would be so coarse in texture as to appear nothing more than a patch of gravelly soil.

The nitrate of silver bath was of the common strength, first rendered neutral, and then slightly acid with glacial acetic acid. The developer was a weak aqueous solution of pyrogallic acid with glacial acetic acid, but no alcohol. As to the collodion, I could use almost any of the commercial samples, provided they gave a tenacious parchment-like film. But one of the great secrets of success lay in the time which the sensitised plate was kept in the silver bath. The duration of dipping was suited to the collodion for certain chemical reasons, which I have not space in this note to discuss, nor can I do more than give this simple outline of the micro-photographic instrument and its manipulation.

There is another application of micro-photography of great value to the microscopist. It consists in the photographing of 'finders' on a square space of one inch divided into squares of one hundredth of an inch. Each square contains two sets of numbers from the unit up to one hundred running in opposite directions across the surface. These 'finders' are all

The focussing, which is easily effected with impressions of the ordinary size, requires the employment of a microscope when the image thrown on the surface of the ground glass is of such a very small size.

The usual dark slide of the camera is replaced by a support which keeps in a horizontal position a plate of collodionised glass, and carries besides twenty little object-glasses intended to produce as many microscopic reductions of the negative. Afterwards, by the aid of a diamond this glass plate is cut into twenty pieces, each containing a picture. We shall confine ourselves to mentioning these difficulties without entering into full technical details.

During the war the processes were different, especially in magnifying the photographs for the purpose of being read in the besieged capital.

taken in a mathematically accurate uniform position on glass slips of perfectly uniform size. Each slip fits into its allotted position on the stage of all well-formed microscopes, and puts it in the power of the microscopist to determine, so to speak, the longitude and latitude of a single diatom, or group of diatomaceæ, or any minute object that may come within the field of his instrument. But this is not all. Should the microscopist make a discovery, the finder enables him to verify it. Let us suppose that some new diatom occupies the field of his microscope. It is a minute object quite invisible to the naked eye, and most difficult to find among the countless groups of its fellows. But the student, in order to fix its position, removes the slip from the stage and replaces it by the finder, when he at once reads its number. This number he registers, and thus places it in the power of any savant to whom the slip may be sent, to hit upon the position of the diatom at once, by using his finder, bringing the number into the field and replacing the finder by the microscopic slip.—ED.

Thirty or forty copies of the microscopic despatches were usually printed and sent by as many pigeons. More than one hundred thousand of them were thus sent to Paris during the siege.

As soon as the small tube was received at the telegraph office, MM. Cornu & Mercadier proceeded to open it with a knife. The photographic films were carefully placed in a small basin of water in which were put a few drops of ammonia. In this liquid the despatches unrolled themselves. They were then dried and placed between two plates of glass. It only then remained to lay them on the stage plate of a photo-electric microscope. The preceding engraving (fig. 58) represents one of these interesting meetings for the purpose of transcribing the microscopic despatches. The image on the film of collodion is there thrown upon a screen by means of a photo-electric apparatus, which is, in fact, a very powerful magic lantern. The almost invisible letters are sufficiently magnified to enable the copyists to reproduce them on paper.

When the despatches were numerous the reading of them was a somewhat slow process, but as each film contained a great number of pages or little squares, they could be divided and read at the same time by the use of several microscopes.

Messieurs Cornu and Mercadier carried the process of

reading the despatches by means of the microscope to great perfection. The film of collodion pressed between two glass plates was placed upon the stage of the microscope to which a mechanical arrangement gave both a horizontal and a vertical movement. Each part of the despatch passed slowly over the field of the microscope. The characters displayed themselves upon the screen sufficiently magnified to be read and copied. The arrangement and process of reading the despatches lasted about four hours ; it required besides several hours to copy them. Messieurs Cornu and Mercadier tried to photograph the characters directly as enlarged and thrown upon the screen, but did not succeed in doing so in their first attempts.

It is certain that improvements in the process would have progressed rapidly had not the severe cold of the winter caused the arrival of the pigeons to become more and more rare during the siege.

Though details concerning these birds lie beyond our subject, which is essentially photographic, we do not think we can omit making a few remarks about them ; for having described the letters, it is only right to say a few words about the postmen.

The severity of the season is not the sole obstacle which prevents the duties of the messenger birds from

being properly performed; they are exposed to other dangers on their passages, birds of prey being their most formidable enemies.

Doubtless among the many carrier-pigeons which never return to their home, there are a certain number which

Fig 59.

CHINESE WHISTLES ATTACHED TO CARRIER-PIGEONS.

have been the victims of those aerial pirates, the hawks. The Chinese,[1] who often show considerable ingenuity in

[1] When in Pekin I was for some time puzzled by the musical tones which came from a number of birds whirling in circles over the city. The mystic sounds were at length explained to me by a Chinaman who owned pigeons and who armed them with the bamboo pipes used to scare away birds of prey.—ED.

the plans which they adopt, have invented a very ingenious system to protect the carrier-pigeons, which are much employed in the Celestial Empire, from the birds of prey. They attach to the root of the tail of the messenger birds a set of very light bamboo whistles, as represented by fig. 59. When the pigeon flies, the air rushes into these little tubes ; this produces vibrations, causing a sharp and continued sound. If the birds travel in companies, the sets of whistles with which they are provided produce a noisy concert. People who have lived for some time in China, and especially at Pekin, report that in the country they have often heard the whistling and booming produced by these little tubes of bamboo belonging to the carrier-pigeons, without at first being able to account for the unexpected sound which seemed to descend from the skies.

It seems to us that this process deserves attention. Everything should be done to perfect the organisation of the aerial post, which at present occupies the attention of many. We hope that this organisation may soon be ready to work, and that the history of the pigeons of the siege may be an encouragement to future breeders of these interesting and useful birds.

We should not forget that in the fatal hour when France was invaded by her enemies, photography com-

Fig. 60 [Page 247

DEPARTURE OF CARRIER PIGEONS FROM THE CHAMPS-ELYSÉES, PARIS.

pleting the wonderful services rendered by the pigeons, was of great advantage to thousands of the besieged, imprisoned during five months by the German armies.

Let us hope that the teachings of the past will be fruitful in the future, and that if France is again engaged in one of these bloody conflicts, the carrier-pigeons will play their modest part and give new assistance. This time we would fain believe they will only be the messengers of victory and good news.

Breeding and training pigeons is the necessary complement to microscopic photography, as employed in making up and forwarding despatches during time of war.

At present these useful winged messengers are not neglected, and quite recently an attempt has been made to encourage the breeding of them by valuable prizes offered for competition. During the year 1873, the people of Paris have shown their approval of these encouragements by attending the departures of the pigeons which take place before the Palace of Industry from time to time (fig. 60). Such experiments cannot be too much encouraged. Carrier-pigeons are the safest bearers of these microscopic despatches, which convey to the besieged detailed news and explicit orders.

In certain cases very remarkable results were attained

by means of the aerial post. Here is an example mentioned by M. Dagron :—'When nothing interfered with the flight of the pigeons,' says this talented operator, 'the rapidity of the photographic correspondence was truly marvellous. I can myself give an example. Wanting some chemicals, especially gun cotton, which I could not procure at Bordeaux, I ordered them by pigeon despatch from Messrs. Poulenc and Wittmann, of Paris, on January 18, 1871, begging them to forward them by first balloon. On January 24th the articles were delivered to me in Bordeaux. The pigeon had only taken twelve hours to pass from Poitiers to Paris.' The electric telegraph and railway could not have done better.

This admirable use of microscopic photography, bringing to the aerial post by balloons and pigeons the indispensable complement of light messages, is a fine example of the close correlation which unites the different branches of modern science, and which enables them at a given moment to co-operate towards the same result.

CHAPTER VII.

ASTRONOMICAL PHOTOGRAPHY.

CELESTIAL PHOTOGRAPHY—DIFFICULTIES OF ASTRONOMICAL PHOTOGRAPHIC OPERATIONS—MESSRS. WARREN DE LA RUE, RUTHERFURD, GRUBB, ETC.—THE LUNAR MOUNTAINS—THE SPOTS ON THE SUN, ETC.—IMPORTANCE OF PHOTOGRAPHIC DOCUMENTS FOR THE HISTORY OF THE HEAVENS.

PHOTOGRAPHY furnishes inestimable resources to all the sciences. We have seen that it places under the eyes of the naturalist the enlarged images of the grains of the pollen of a flower, *infusoria*, and of forms of vegetable and animal life invisible to the naked eye.

Meteorology, as we shall show in the sequel, makes use of it to register with mathematical precision, with a constancy which nothing interrupts, all the variations of the barometer, of the thermometer, and of the magnetic needle. Geology finds it a useful assistant in reproducing, with an exactness which nothing can approach, the inclinations of the various strata it would study. The engineer employs it like a mirror, in which he sees from day to day the state of the works he is employed in executing.

The applications of photography to astronomy in the study of the heavens are not less valuable. They furnish a remarkable assistance to those who devote themselves to the task of sounding the depths of the firmament.

Though it is true that these applications are new and recent, it may be remembered that they were foreseen by Arago from the time of Daguerre. In his notice of the Daguerreotype, the illustrious Perpetual Secretary of the Academy of Sciences reports with admiration that the inventor of the diorama, at his request, had obtained an image of the moon on the sensitive silver plate.

To reproduce at the present day the images of the celestial orbs by photography, the operator may employ one of the powerful telescopes which are to be found in all the principal observatories of the civilised world.

It is indispensable to make use of a reflecting telescope having a speculum formed of glass, silvered according to Foucault's process. This instrument is achromatic, that is, its optical coincides with its chemical focus. The focussing of it therefore presents no difficulty.

The telescope thus constructed should be mounted equatorially, as astronomers say, *i.e.* supplied with a moving power which during the operation follows exactly

the motion of the celestial body the image of which is being taken. This movement, also, must be in the plane of the celestial equator—the same as that in which the star or planet moves.

When an astronomer wishes to obtain the photograph of celestial bodies by means of Foucault's reflecting telescope, he removes from the instrument the eye-piece generally used and replaces it by a double ring, in the central part of which is fixed the collodionised glass-plate intended to receive the luminous impression. In order to focus the instrument the collodionised glass is replaced by a piece of ground glass and moved backward and forward until the image is sharply defined. At this moment the movable screen is quickly withdrawn; the sensitive surface is exposed; it receives directly the luminous rays which reproduce faithfully the image of the celestial body millions of miles distant from our humble planet. The negative is fixed by the ordinary means, and will print an unlimited number of positive impressions on photographic paper.

Mr. Warrren de la Rue is one of the astronomers who first attained the most perfect results of photographic astronomy. He managed to take an impression of the constellation of the Pleiades of remarkable sharpness, but he did not succeed in getting an impression of any of the

nebulæ. These clouds of suns are scattered through the heavens at such distances from our humble spheroid that the human mind, staggered when it would regard them, feels itself almost powerless to comprehend these measures of immensity.

When the sky is clear, when no cloud mars the purity of the vault of heaven, the photographic impressions of the planets give fairly satisfactory results; but the image is never perfectly sharp and distinct. These orbs, endowed with a weak actinic power, only leave an uncertain trace on the negative; the fixed stars, true luminous points placed in the heavens at enormous distances from the earth and from our observatories, leave upon the collodionised glass the trace of an excessively thin line, and sometimes it is very irregular if the atmosphere of the earth is overcharged with vapour. After having fixed on a photographic plate the trace of these stars, it is necessary to assist the eye with a good microscope to discover it. Our eye is as powerless to perceive it without the help of an instrument as we are to appreciate the greatness or the real distance of these suns lost in the depth of the heavens.

In spite of the difficulties which the photography of the planets offers, Mr. Warren de la Rue, thanks to persevering labours and ingenious combinations, has

succeeded to a certain extent. This learned astronomer succeeded, by the aid of an equatorial mechanism admirably regulated, in keeping the image of the moving star for several minutes in the centre of the field of view of the telescope which moved along with it, and his efforts were crowned with legitimate success.

He was able to take the photograph of Jupiter with his parallel zones. Nor has it been beyond the powers of this talented operator to fix upon the collodion the rough surface of the planet Mars and the mysterious ring of Saturn.

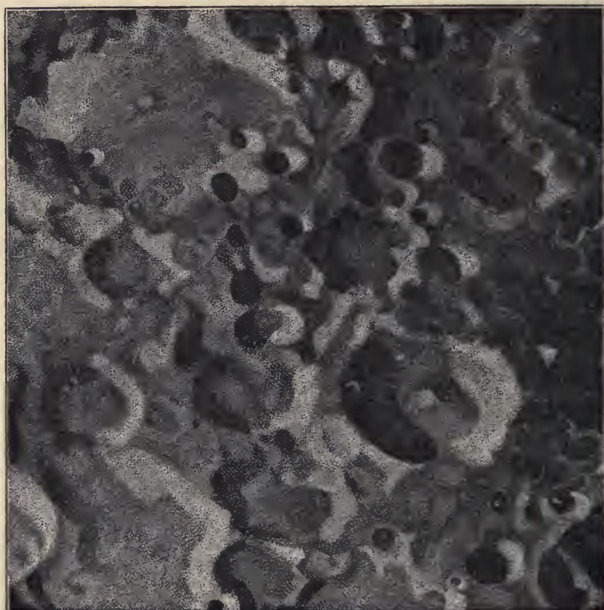
If the photography of planets offers serious difficulties, that of the moon, which alters its place in the heavens much more rapidly, presents obstacles still greater; but great though they be, they have been surmounted by Secchi, De la Rue, Rutherfurd, Grubb, and some other distinguished astronomers, as skilled in the management of photographic apparatus as in their knowledge of the heavens.

We place before the eyes of our readers the facsimile of the photograph of a very interesting region of our satellite. Our engraving has the merit of reproducing exactly the appearance of the impression obtained by the English astronomer (fig. 61).

Some years ago Mr. Grubb succeeded in photograph-

ing the moon as correctly as if she had been sitting for her portrait in his own studio. Only as the Dublin astronomer could not utter the usual caution—Don't move—it was necessary that the telescope at the focus of which the image was to be fixed should move at exactly the

Fig. 61.



LUNAR MOUNTAINS. AFTER A PHOTOGRAPH BY MR. WARREN DE LA RUE.

same rate as the sitter. Mechanically such a result is not easy to attain with rigorous correctness.

The great telescope constructed by Mr. Grubb for the Government observatory at Melbourne is a marvel of mechanism. The speculum is about 46 inches in diameter, with a focal length of 30 feet, and its weight, including all its mountings, is about two tons. The tube is surrounded by a trellis-work of flat iron, but it is chiefly composed of bars of steel firmly fixed to solid rings of iron, the whole weighing about ten tons. To render the movement as easy as possible, all the bearings are supported by an apparatus to prevent friction. This telescope is so easy to manage, notwithstanding its enormous dimensions, that two persons can turn it round either vertically or horizontally in forty-five seconds.

This instrument, which takes in the whole hemisphere, is put in motion by an excellent clock. In the course of the year 1869 Mr. Grubb presented to the French Photographic Society photographs of the moon taken by the aid of this huge telescope, in a camera mounted at the end of the trellis-work tube. The time of exposure varied from half a second to two seconds, the brilliantly-lighted part of the moon requiring a shorter exposure than the parts in the neighbourhood of the dark side.

Up to this time, as we have said, Mr. de la Rue in England and Secchi in Rome had alone succeeded

in producing photographs of the moon worthy of the attention of natural philosophers or of astronomers.

The impressions obtained by these gigantic instruments of Mr. Grubb in the serene atmosphere of Australia have greatly surpassed the highest efforts of European art.

It is impossible to avoid a certain emotion in contemplating the negative of a lunar photograph, in admiring the raised appearance of the mountains of our satellite, and tracing upon the collodion the dark obscurities formed by its valleys. It is quite certain that it is mathematically correct, for it is the light from its surface that has winged its flight to our globe to print the picture of the rugged peaks, the craters, the strange hollows which appear on the surface of the orb of night.

Marvellous result of science, which takes the minute counterpart of the silvery and mysterious disc suspended so far from us in the dark azure of the firmament!

There has been rapid and important progress in this fertile field. Mr. Rutherfurd has lately obtained photographs of the moon of the greatest merit. Some impressions were presented to the Academy of Sciences in November 1872, by M. Faye, who, in offering these remarkable specimens, gave some details of the highest interest, which we are happy to borrow from him :—

'These impressions, striking marks of the progress which astronomical photography has made in the United States, have been obtained by means of a lens of 13 inches' aperture, specially achromatised. From the negative, which was about four inches in diameter, a positive was taken of the same size, and this was then magnified by a powerful solar microscope. The exposure of the original negatives varied from one quarter of a second at full moon to two seconds at the first and last quarters.

'The photographic lens was moved during the time of exposure at the same rate as the apparent motion of the moon, by clockwork of great accuracy.

'A glance at these magnificent impressions is sufficient to make the service they may render to lunar geology appreciated.

'The luminous lines, like cracks forming parts of a great circle, intersect one another at angles which it is possible to measure with a certain amount of exactness. By the aid of an outline map on which are marked the lines of latitude and longitude, calculated previously so as to correspond with the particular phase of the moon, and drawn upon a sheet of transparent paper, and then applied to these beautiful maps, the geometrical elements of these arcs in relation to the lunar

equator can be obtained. The circles, the craters, and even the smallest circular hollows which the surface of the moon exhibits in great numbers, are there represented on a large scale with a startling fidelity which no printed chart could equal. One can there study at leisure the numerous varieties of these different objects so similar at first sight to our extinct volcanoes, and yet so different in some respects from their terrestrial representatives. Photography shows the heights of these mountains by showing the length of their shadows as well as their horizontal dimensions.

Among the lunar formations best represented by photography are what are called seas, the want of light or rather the dull colour of which strikingly contrasts with the brightness of the mountainous parts. One is struck by their aspect quite as vividly as by the direct inspection of the moon, with the idea that there are before you vast discharges of fluid matter, which have covered up the previous inequalities of the surface, leaving here and there on its coasts some vestiges of primitive cycles.

If photographs of the moon are fruitful in information, those of the sun are not less rich in their teachings; and the spots which sully the purity of the orb of day have been imprinted on the glass plate of the camera.

Celestial photography has recently been applied at

Harvard College in the United States to the double stars, in order to determine by micrometric measurement their relative angle of position and distance.

In the photographic reproduction of the stars recently undertaken by Mr. Rutherfurd, it has been found necessary to take special precautions with the sensitive plate, so as to distinguish these impressions from accidental markings on the film of collodion. To prevent any chance of error, Mr. Rutherfurd takes a double image of each luminous body by stopping the motion of the telescope for about half a minute between the first and second exposure, so that each star is represented by two contiguous points on the negative, a peculiarity which distinguishes them from any spot formed accidentally on the film. By this means a very correct though very delicate map of the heavens is obtained, from which trustworthy measurements may be made. Professor Peirce says with justice this addition to astronomical research is a step which leaves far behind it all that has been previously accomplished. Photographs preserve for comparison with future researches the exact relative positions of the stars at the present time. The photographs once taken constitute indisputable facts beyond the influence of any personal defect of observation, and provide for future ages the present actual position of the stars.

Mr. Asaph Hall, who has taken part with Professor Bond in measuring the photographic images as well as in the calculations of these measurements, has quite recently submitted the photographic method to severe tests in order to determine its value in its application to the observation of the transit of Venus. He seems not to approve of photography as applied to observations of the stars from its want of rapidity; but he admits that in the case of an eclipse of the sun, or of the passage of a planet across the sun's disc, it possesses very great advantages, especially for the observation of the exterior or interior contacts of the planet with the sun's limb, and that any error to which it may be liable is worthy of the most serious investigation. The observation of the contact is uncertain in consequence of the irradiation; it only lasts for an instant, and should the observer fail to notice it, the registration of the phenomenon is irredeemably lost at that particular station, and all the long and expensive preparations are rendered useless.

On the other hand, when the sky is clear a photographic image can be obtained in an instant, and can be repeated during the whole course of the transit; and when even the contacts have not been caught, results not less valuable may be obtained if the data collected on

the photographic plates can be correctly calculated. Of this we shall shortly show the perfect practicability. We may announce for certain that the transit of Venus will be depicted by photography, for in England, in France, in Russia, and in America, much activity is displayed in making preparations to obtain photographic pictures of it.[1]

Nothing can more solidly establish the right of photographic observations to be considered one of the most important aids of scientific research than the accounts of the last eclipses of the sun. It will be recollected that in 1860 for the first time the solar origin of the protuberances was put beyond doubt solely by photography, which preserved a faithful representation of the movement of the moon in relation to these protuberances.

The photographs of Tennant at Guntoor, and of Vogel at Aden in 1868, and those also of the American astronomers at Burlington and at Ottumwa, Iowa, in 1869, under the superintendence of Professors Morton and Mayer, have fully confirmed these conclusions.

It was also in the same manner that the great problem of the solar origin of that part of the corona which

[1] As the reader is doubtless well aware, the attempts to photograph the Transit were eminently successful, especially with the daguerreotype process.

extends more than a million of miles beyond the body of the sun was definitively solved by the photographic observations of Colonel Tennant and Lord Lindsay in 1871, after having for many years furnished matter for numerous discussions.

If photography, as will be seen by these striking facts, now renders great services to astronomy, it will in all probability render yet greater in the immediate future, for it is still unable to depict all the celestial bodies.

'The nebulæ and the comets,' says Mr. Warren de la Rue, 'have not fallen into the domain of this art, though perhaps no branch of astronomy would have more to gain if we could succeed in extending this mode of observation to these bodies. In theory, and even in practice, there is no limit to the sensitiveness of a photographic plate. At the same time, there still exist great difficulties in photographing the planets, which it is necessary to overcome before photography can for any special purpose reproduce their phases and their physical characteristics, but even in this also there is great hope of final success. The chief obstacle to success arises from atmospheric currents which continually change the position of the image on the sensitive plate. The structure of the sensitive film is also a cause of trouble with very small objects, though a photograph taken at Cranford some

time ago of the occultation of Saturn by the moon, shows the ring of the planet in such a manner as to afford great hopes for the future.'

No doubt science will succeed in triumphing over these obstacles, and photography applied to the whole heavens will crown the edifice of modern astronomy.

Some astronomers, however, are not of this opinion, and we believe it may be useful to state the opinions of the venerable Maedler, formerly director of the Observatory of Dorpat, on the subject of photographic astronomy:—'The greater number of those who hear me,' said the great astronomer, in a lecture given in 1868, 'may still remember that immediately after the discovery of photography we heard hopes expressed which resembled nothing so much as those of Descartes and his contemporaries after the discovery of the astronomical telescope. They compassionated the unfortunate philosophers who had passed all their lives without interruption in observing, in measuring, and in drawing.

'Not only would the same thing, they said, be done without trouble and in much less time, but the results obtained would be much superior, much more exact, and much more detailed than formerly. What has taken me seven years, the determination of the extent of the surface of the moon, would be better done in seven seconds.

Now thirty years have elapsed since the discovery of Daguerre, how many of these ambitious hopes have been fulfilled?

'Warren de la Rue, in England, and William Cranch Bond, in America, have courageously put their hands to the work. They have adapted powerful astronomical telescopes to photographic apparatus, they have also succeeded in giving to their instruments a motion corresponding to that of the celestial bodies, of which they propose to produce the image during the short time necessary for the production of the impression.

'Thus the moon has been photographed in her different phases, but the details are still inferior to those which an able observer can determine. Bond has been engaged with the fixed stars; he made use of an astronomical telescope which enabled him to perceive the stars of the fourteenth magnitude, but he was only able to obtain weak and scarcely visible images of those of the fifth magnitude.

'We could mention, it is true, very valuable pictures which we owe to astronomical photography; but it is not the details of the starry heavens which can be acquired and preserved in this manner, but the phenomena connected with objects long known and giving a powerful light.

'I shall mention in the first place the spots on the sun, the representation of which only requires the smallest fraction of a second, and which have been produced with great exactness. But, even in this case, details have not been obtained, such as good observers, accustomed to these phenomena, have been able to produce, but there is obtained, what is very important in this case, an image of the sun at a specified moment, and, if we may be permitted to use an expression of Sir John Herschel, we compel the sun to write its own history.

'These experiments will be, or, to speak more correctly, have already been, very useful in total eclipses of the sun. There is no draughtsman, however expeditious he might be, who could, during two or three minutes, the ordinary duration of the phenomenon, do what Warren de la Rue did in Spain at the last eclipse of the sun, because, if everything has been prepared, there can be obtained not only three but twelve or fifteen images of a phenomenon which passes away so rapidly.

'As for the planets, even the larger ones, photography is of little use, and will teach us very little that is new. It will be of still less use when applied to the fixed stars. The groups of the Pleiades and of Orion have been photographed, and these constellations may certainly be recognised in the images obtained, but a good

eye, even without the aid of lenses, will see more in the heavens than is shown by photography.'

We have considered it right to repeat these severe criticisms of Maedler without altogether admitting their correctness. We think, on the contrary, that photography is one of the great resources of modern astronomy.

There is nothing so hurtful or so fatal to progress, says Mr. Warren de la Rue, as false data, because they are sometimes perpetuated for ages.[1]

The prodigies accomplished by modern opticians will be continued by our descendants, and the magnificent telescopes of our observatories, which diminish the apparent distance of the moon to such an extent that we can now study the constitution of our satellite as if it were at a less distance than three hundred miles, are only as yet, we cannot doubt, specimens of the infancy

[1] It cannot be denied that a photographic impression of any object is infinitely inferior to the object as we see it with the naked eye, whether the object be celestial or terrestrial. Nevertheless, photography has already done much, and is full of the highest promise of future achievements as the only known means by which may be preserved an absolutely trustworthy register of many of the most important phenomena of the heavens. It has furnished the astronomer with charts of the moon; the phenomena connected with solar eclipses; the positions of the spots on the sun's disc at certain fixed dates; the spectra of heavenly bodies, showing in unerring lines the presence, in their luminous envelopes, of certain elements which are known to us. Without the aid of photography, the lines in the solar spectrum could not have been fully observed, as the photograph reveals many lines which are invisible to the naked eye.—Ed.

of an art which reckons among its founders Galileo and Newton

When the science of astronomical optics has accomplished still more, photography, closely following its footsteps, will produce marvels of which the boldest imagination can hardly have a suspicion. 'There is no limit to the sensitiveness of a photographic plate,' we may say at present with an eminent astronomer; consequently the images of the orbs of heaven fixed in the focus of the camera will, perhaps, permit us to study the most minute details of the geology of the planetary bodies.

If it be true, as Leibnitz says, that the present is big with the fate of the future, we shall comprehend, by the importance of results already obtained, what we have a right to expect may be attained by the astronomers of the future.

CHAPTER VIII.

PHOTOGRAPHIC REGISTERING INSTRUMENTS.

IMPORTANCE OF REGISTERING INSTRUMENTS—PHOTOGRAPHIC BAROMETERS AND THERMOMETERS—THE REGISTRATION OF THE VIBRATIONS OF THE MAGNETIC NEEDLE—RONALD'S PHOTO-ELECTROGRAPH—PHOTOGRAPHIC PHOTOMETRY—PHOTOGRAPHY OF COLUMNS OF WATER RAISED BY A TORPEDO—OF THE PHENOMENA OF THE INTERFERENCE OF THE RAYS OF THE SPECTRUM.

AMONG the physical sciences there are some, of which the progress is, so to say, intermittent, which burst out into veritable revolutions which suddenly transform them; there are others, where great events are rare, where the long-continued patience of the observer is, to a certain extent, a substitute for the inspiration originating accidentally in the brain of an inventive genius.

Chemistry has had its Lavoisier, who, by the theory of combustion, by the analysis of the atmosphere, suddenly marked a new era in this fertile branch of human knowledge.

Physical science has had its Volta, who opened to it a new horizon by originating the electric pile. But

there are other sciences where such progress cannot be suddenly manifested.

Meteorology, for example, which has for its object to study the laws of the mechanism of the atmosphere, ought to determine every day the temperature, the humidity of the air; note the variations of the barometer, the oscillations of the magnetic needle; the domain in which it acts is not that of rapid conquests; a science of observation, it cannot expect anything from the fortunate accidents which sometimes occur when making experiments.

The work of those who devote themselves to it consists essentially in gathering up each day and every hour rigorously exact lists of figures; the hope which animates them is to see stations of observation multiplied over every continent. They will leave to their successors the patient investigations made during their lives—happy if correlation and comparison of their results lead to the discovery of some of the fundamental laws which preside over the movements of the atmosphere.

In presence of the necessity of consulting, as frequently as possible, and at an increased number of meteorological stations, the various instruments by which the atmosphere is questioned, it was soon observed that there would be a very great advantage in substituting for the labour of man that of machines.

How can we condemn an observer, however conscientious he may be, to read off several times every hour and for entire days together the degree of the thermometer, the height of the barometer, to take a note of the movements of the magnetic needle and the rotations of the weathercock? But it is of importance to the progress of meteorology that these daily observations be executed with the precision which ought to characterise every truly scientific document.

What man cannot do is accomplished by a machine. To obtain this ingenious mechanism capable of leaving on paper traces of the movement of the mercury in the barometer and the thermometer at every hour of the day and of the night, of indicating the slightest disturbance which may occur in the most delicate parts of the most exact instruments, recourse has been had to the valuable aid of photography. The art has been applied to those meteorological instruments which write down their own variations at every moment, and which are called self-registering.

The idea of employing for the study of meteorological phenomena apparatus so arranged that they may themselves mark the traces of the influences to which they are subjected is not new. It goes as far back as Magellan, who, in 1782, had constructed thermometers

and barometers which registered all the changes caused by the variations of the state of the atmosphere.

Registration by photography, such as is now accomplished in a great number of observatories, offers the advantage of doing away with the complicated mechanism which every other method required, whether mechanical or by electro-magnetism. This mode of registering is chiefly utilised for the variations of the barometer and the thermometer, and the oscillations of the magnetic needle.

It is well known that at the upper surface of the column of mercury in the barometer there is an empty space known as the Torricellian Vacuum. If a light be placed—that of gas or of a petroleum lamp for example—before the barometer and a convex lens between them to converge the rays of light on the upper part of the tube of the barometer, an image of the lighted space immediately above the mercury would be thrown upon a piece of sensitised paper placed behind it, and this image would vary at each instant with the variations of the level of the mercury of the barometer.

The registering thermometer or thermograph is arranged almost in the same manner, only it is necessary that the lamp should be placed at some distance from the apparatus in order that the heat emitted by it may

not act upon the instrument; besides this the light does not pass through the empty space above the mercury, but through a small bubble of air which has been previously introduced into the thin mercurial column. The light thus transmitted produces a mark like a point on the paper.

In these instruments the sensitised paper is stretched on a drum which regularly revolves by means of clockwork, and the traces of the variations of the height of the mercury in the barometer and the thermometer are found marked by a continuous line, when the paper is withdrawn and submitted to the operations necessary to fix the image.

The arrangement of the mechanism varies according to the mode of registering applied to different instruments. In order to adapt photography to the registration of the variations of the barometer, Mr. Ronalds, and afterwards Mr. Salleron, have adopted the ingenious arrangements which we shall describe.

This self-registering barometer has been called the photographic barometrograph.

An ordinary cistern barometer is suspended vertically by an iron collar. Before this instrument is a convex lens which concentrates the light of an argand lamp or a jet of gas on its upper part. The upper part

of the tube of the barometer is provided with a transparent scale of glass divided into fiftieths of an inch.

The luminous ray passes through this scale and above the surface of the mercurial column, and then through an achromatic object-glass, projecting on to a sheet of sensitised paper the image of the graduated scale, and also of the movable surface of the mercury.

The photographic paper is fixed to a frame which moves upon a carrier in a plane at right angles to the axis of the object-glass. Clockwork is applied to the frame so that it moves its own length in twenty-four hours.

It results from the whole of these arrangements, says M. Pouriau, to whom we owe an excellent work on self-registering instruments, that the light thrown on the tube of the barometer is arrested by the mercurial column forming a screen the image of which, passing through a lens, falls upon the sensitised paper. The representation of the convex or concave surface of the mercury, and the divisions of the scale as marked upon the tube of the barometer, are at the same time thrown upon the sheet of paper which receives their images through the opening admitting the rays of light from the lamp. This sheet of paper fixed to the carrier

partakes of its movement, and from this it follows that each part of it comes in succession before the opening and is impressed with the image.

At the close of each day the sheet of paper is taken out of the frame; the impression is then fixed by the ordinary photographic process; the part affected by the luminous rays forms an undulating line drawn by the upper surface of the mercurial column, the height of which is easily measured by the divisions of the scale printed upon it at the same time.

After the impression has been fixed on the paper a sheet of glass is applied to it divided by lines into twenty-four equal parts, and if the hour is known at which the operation commenced, it is easy to determine with the most perfect exactness the hour corresponding to all the points of the line.

When a photographic registering thermometer is required, in place of the tube of the barometer of which we have been speaking, a thermometer having the divisions of the scale cut upon glass is used. The upper surface of the mercury and the divisions of the scale are again photographed at the same time. The thermometer is curved in such a manner as to allow the bulb being passed through an opening in the wall of the room, and thus exposed to the influence

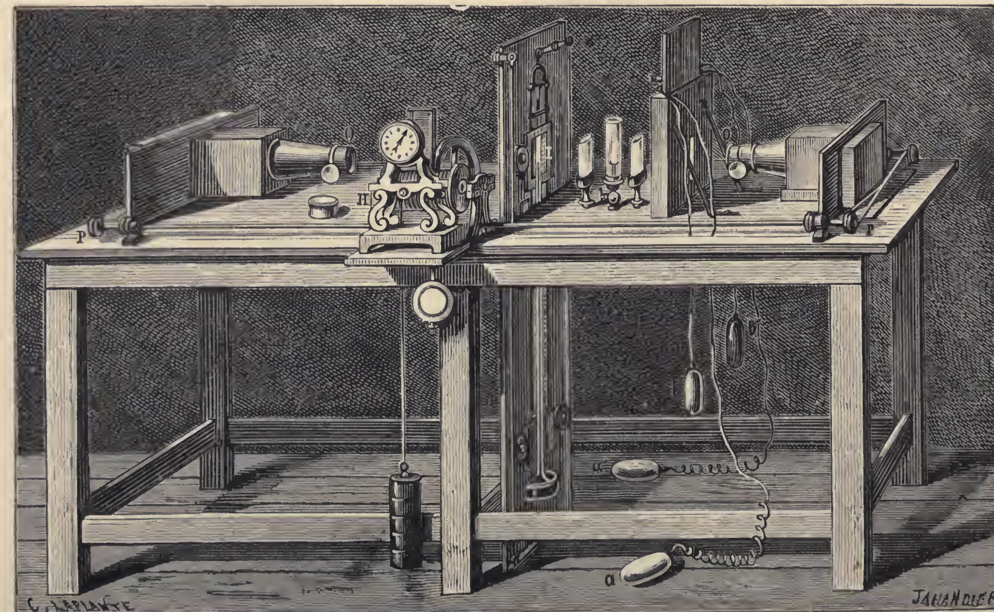


FIG. 62

[Page 275

SALLERON'S PHOTOGRAPHIC BAROMETER AND THERMOMETER.

of the external temperature which it is intended to measure.

M. Salleron has recently constructed, for the Observatory at Kew, a very fine photographic self-registering apparatus for the variations both of the barometer and the thermometer at the same time; after what we have just said, a description of it will be easily understood.

The arrangements of this apparatus are represented on the right and left of the engraving, fig. 62.

The mercurial barometer is at the middle of the table, its upper part being represented at I. O is the object-glass of the photographic camera. H is the clock-work which moves the slide carrying the photographic paper by means of the rod P.

This magnificent apparatus leaves far behind it all previous arrangements; for not only does it act as a barometrograph, but it also registers the temperature and the hygrometrical variations.

The thermometrograph is shown to the right of our engraving. It is upon a different plan to that of which we have just spoken. The metallic reservoir of air, *a*, is sunk into the earth, and remains at a constant temperature; it is hollow and communicates by a tube with one of the branches of a tube which is filled with

mercury, and rises between the light and the object-glass, O. The other branch of the tube is in connection with a second reservoir of air, *b*, which remains in the surrounding atmosphere. The difference of the temperatures of the two reservoirs of air is shown by a movement of the mercury in the glass tube, the light passes over the surface of the fluid metal and impresses the photographic paper after passing through the object-glass O. It traces upon the moving photographic paper an undulating line which represents the variations of the mercury in the tube, and consequently the temperature of the air.

Another similar arrangement, *a′* and *b′*, acts as a registering psychrometer or measurer of the amount of watery vapour in the atmosphere. The reservoir of air, *a′*, is sunk in the earth, the other reservoir, *b′*, which is kept moist, remains exposed to the atmosphere; both again communicate by means of a tube with two branches of a glass tube containing mercury, over the surface of which the luminous rays pass.

Photography is not only applied to the registration of the variations of the barometer and thermometer, it may also be made use of to register the declination of the magnetic needle, as Dr. Brooke has proved by the construction of an apparatus equally ingenious as

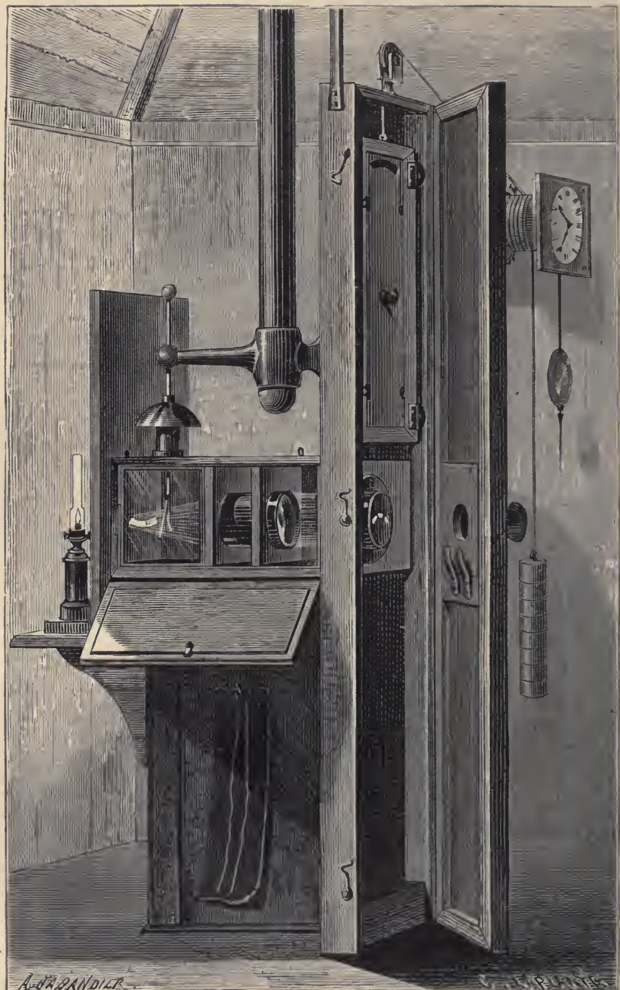


FIG. 63 [Page 277

PHOTO-ELECTROGRAPHIC INSTRUMENT AT KEW OBSERVATORY, FOR REGISTERING THE STATE AND VARIATIONS OF THE ELECTRICITY OF THE AIR.

correct, and which is constantly in use at the Observatory at Greenwich.

The magnetic needle carries at its extremity a very small mirror on which the light of a lamp falls. The reflected ray is thrown upon a piece of sensitised paper placed in a camera, and it there traces an arc greater or less in proportion to its distance from the photographic paper. If the magnetic needle makes the slightest movement, the mark of the reflected ray changes its place upon the screen—it follows faithfully the motion of the needle, and does not fail to note its least oscillation.

The sensitive paper is not fixed, but is attached to a cylinder which performs one revolution upon its axis in twenty-four hours. At each moment the reflection of the mirror is traced upon the photographic sheet, which at the end of the day is developed and fixed by the ordinary processes.

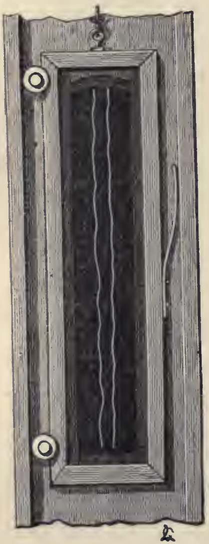
Thus, there is obtained a continuous line which indicates the movements of the luminous ray reflected by the mirror attached to the magnetic needle, and which shows its slightest motion during the course of the twenty-four hours.

At the Observatory at Kew, an analogous system is made use of to register the variations of the electrical condition of the atmosphere. The photo-electrograph

(fig. 63) consists of a lightning conductor in connection with an ordinary electroscope, the gold leaves of which, as is well known, are separated more or less from one another according to the greater or less quantity of free electricity in the air.

The leaves of gold illuminated by a lamp as seen in our engraving intercept the light and throw the shadows on the sensitive paper, which has a regular downward motion, produced by clockwork. Thus are obtained two undulating lines which approach or separate at every hour of the day, and show with absolute correctness the electric state of the atmosphere at every moment (fig. 64).

Fig. 64.



UNDULATING LINES TRACED ON THE CARRIER OF THE ELECTROGRAPH.

It is to Francis Ronalds that the honour of having invented this admirable system of registering belongs; this photo-electrograph, as we have said, is used at Kew, and marks down night and day, and from year to year, the slightest changes in the electrical state of the atmosphere.

Photometry is another branch of physical science which has found a powerful assistant in the operations of the photographer.

When it is desired to measure the intensity of two sources of light, they are made both to shine at the same time, and the strength of the lights measured by the comparative depth of their shadows. But how can such a measurement be accomplished if the two lights cannot be got to shine at the same time?

Though the comparison is easy between the light of a candle and that of a lamp which may both be made to burn at the same time, how is the student to act if he would measure the relative power of the light of the sun and that of the stars or of the moon? The only means of solving a problem so delicate is by photography.

If a piece of sensitised paper be exposed to the influence of the image formed at the focus of a lens by any source of light, will not the amount of alteration produced on the sensitive surface serve to measure the intensity of the light emitted?[1] The traces of the

[1] 'Intensity of light' is a relative phrase which may refer indefinitely, either to the illuminating power or to the photogenically actinic power of rays of light. Photography supplies an accurate test for the illuminating

luminous source are no longer fugitive like the shadows thrown on the scale of the ordinary photo-meter ; it is durable and permanent, and can be compared with that produced by another light shining at a different time.

Photographic photometry has enabled science to compare the luminous intensity of the solar rays with that of the moon. The orb of day gives a light three hundred times greater than that of the orb of night. Thanks to these processes physical science has been enabled to trace out a new course in domains considered inaccessible before the advent of photography.

Herschel and Edmund Becquerel have been able to study effectually the peculiarities of the solar rays at different hours of the day; and thanks to the employment of photographic paper, the study of the chemical action of light to which these distinguished philosophers have

power of white light ; but when a ray of white light is broken up and the photographer attempts to test any of the resulting primary or secondary colours of the spectrum, his observations will afford him no guide to the illuminating power of the light. Thus, for example, a luminous homogeneous yellow light will have no more effect on the sensitive plate than if he had attempted to photograph an object in pitchy darkness; whereas the presence of blue or violet rays, however feeble or imperceptible to the naked eye, may at once be detected by their action on the photographic plate.—ED.

devoted their attention has assumed a place among the most interesting chapters of modern science.

It may be seen by the brief description we have given of the admirable instruments which are employed at some of our observatories how valuable registration by means of photography is, since it enables us to obtain exact and continuous observations; but these instruments are only the birth of yesterday—their use is not very extended, and they will certainly be soon modified and give place to arrangements still more complete and ingenious.

Besides these purposes, photographic registration may be applied to other instruments of observation. For example, there is nothing to prevent the rain-gauge being furnished with an arrangement which would show the variations of its level by means of a tube in connection with the receiving vessel.

The future will prove that registration is the fundamental base of meteorological science, which can never establish its laws unless they are supported by continuous observation. The luminous ray will write in silence the movements and the variations of all the apparatus; the observer will only have to come once each day to consult the sensitised registers, where Nature will, so to say, have marked with its own seal the periodical or inter-

mittent changes to whose mysterious influences it is unceasingly subject.

It must not be supposed, after what we have said, that the photographic system is the only one that can be employed for the registration of atmospherical phenomena: we have only spoken of it because it is in more immediate connection with our subject; and besides, it abounds, as will have been seen, in new and curious appliances.

It may be necessary to add, in order to give the reader a more complete idea of meteorological registration, that in addition to the photographic system, science has often recourse to two other methods; one being based upon mechanical, and the other upon electro-magnetic arrangements.

The first consists in finding in the variations which the instruments experience, the power required to put the registering pencils in motion in such a manner as to enable them to leave their marks. This system is the most ancient, but it is applied with difficulty in consequence of the small amount of force which is at command. The second, as its name implies, is based on the employment of dynamic electricity.

The employment of registration by photography

offers, in a great number of cases, very decided advantages ; but in France there has been considerable opposition shown to this system, which is not represented in our country as it deserves.

The example given by the directors of the Kew Observatory, who have multiplied photographic registering apparatus, and daily use with success and advantage these valuable instruments, should cause our philosophers to have recourse to them more frequently.

Photography is also capable of furnishing to science means of measurement quite new and unexpected. The 'Journal of St. Petersburg' quite recently informed us that instantaneous photography has been utilised by Lieutenant Abnet in some military experiments, where it was wished to calculate the projective force obtained from explosive substances of different natures which are used to fill the torpedo and submarine bombs. In these experiments the torpedo was buried in the sand at low water, and exploded by an electrical current at high water. By means of photography an observation was taken of the height of the column of water thrown into the air, and then at low water again they observed the extent of the crater formed by each

explosion in the sand. In each experiment the photographic camera did its duty in a most satisfactory manner.

Even the delicate optical phenomena of the interference and the diffraction of light have been depicted by photography. Not long ago Professor Clinton showed to his students at the Clarendon laboratory at Oxford a fine series of photographic impressions of the phenomena of interference and diffraction.

These photographs were obtained by receiving the rays of interference on prepared plates instead of the ordinary screen, and then the image was thrown upon a screen in the lecture room by means of the oxyhydrogen light. The impression produced on the sensitive plate was sometimes magnified 2,500 diameters. The subjects thus photographed and thrown upon the screen comprised the phenomena of interference produced by Fresnel's prism, the rays of diffraction by thin edges, the shadows of a straight edge and of an angular aperture, the rays of internal interference in the shadow of a thin wire and of a needle in a small circular disc of light, and the phenomena presented by light when passing through a small circular hole. The professor expressed his conviction that it was the first time photography had been taken advantage of for such public demonstrations.

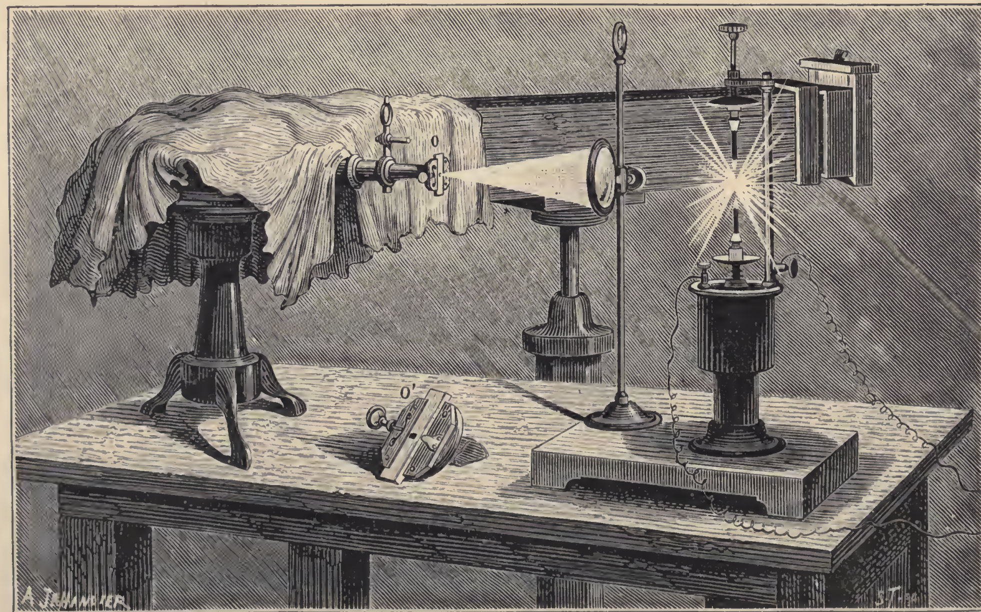


FIG. 65

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LOCKYER'S APPARATUS FOR ANALYSING AN ALLOY OF GOLD AND SILVER BY THE PHOTOGRAPHY OF ITS SPECTRUM.

Photography also offers great advantages to the chemist and to the natural philosopher in studying the rays of the spectrum.

An American, Mr. H. Draper, has recently applied photography to the examination of the violet rays, and also to the space beyond them; he has been able to reveal some new rays until now unknown. He has besides shown that several rays which were considered to be simple are in reality double or triple.

But the English scientist, Mr. Norman Lockyer, has gone still farther; he has made use of the photography of the rays of the spectrum to create the new method of analysis, as ingenious as it is practical, now made use of at the London Mint to examine the alloys of gold and silver.

The alloy of gold and silver is placed in a cavity made in the lower piece of charcoal of an electric lamp (fig. 65).

It is then volatilised when the Voltaic current is put in motion; the luminous pencil of rays passes through an opening, O, which is seen enlarged at O′, and the rays from the gold and silver thrown upon a plate in a camera are photographed directly as indicated in our engraving. The photographs obtained, compared with those previously produced by rays of light from alloys of

known composition, serve to determine the proportion of gold and silver combined in the alloy examined, it being well known that the breadth and length of the image varies in proportion to the number of substances entering into the composition of the alloy.

CHAPTER IX.

THE STEREOSCOPE.

A FEW WORDS ON STEREOSCOPIC VISION—MEANS OF MAKING PHOTOGRAPHIC PRINTS APPEAR IN RELIEF—WHEATSTONE'S STEREOSCOPE — MONOSTEREOSCOPE — HOW STEREOSCOPIC PHOTOGRAPHS ARE PRODUCED.

OUR intention is not to describe the stereoscope here in its relation to optics; we shall merely refer to it as connected with photography.

We consider it right, however, to give some short account of an instrument which enables us to see a design drawn upon a flat surface appear as if it were in relief.

Our eyes show us objects as they are in relief; they are not seen by us as if traced on a plane surface, they appear solid and raised.

The study of the laws of vision shows that this effect is produced by two images seen simultaneously, one being perceived by each eye. Here is an experiment easily made which will show this at once. Place before your eyes a book in a vertical position so that the back

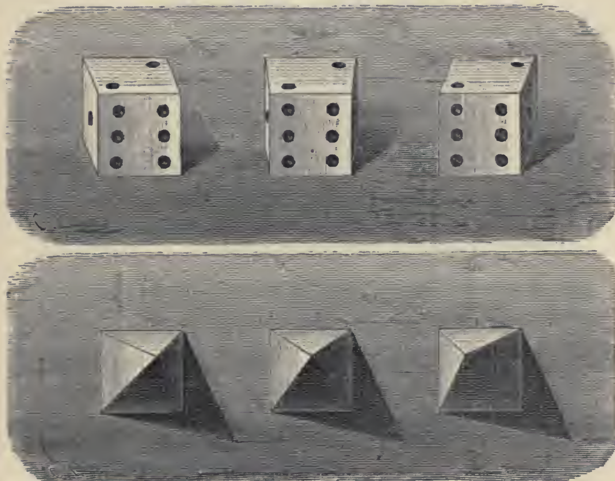
of it is visible. Shut the right eye and open the left, and you will see the left side of the book. After this, if you shut the left eye and open the right, then the back and the right side of the book only will be seen. In order to make the experiment more striking, if a sheet of white paper be stuck on one side of a book bound in red or any other colour, the white or the coloured side will be seen alternately, according as the right or left eye is opened ; when both eyes are open, both sides will be seen. The experiment may, in the same way, be made with a cube or a quadrangular pyramid (fig. 66). Both the right and left faces are seen when both eyes are open, and according as the right or the left eye is shut the cube or the pyramid assumes the appearance of our figures on the right and left. Our minds by the force of habit combine the two pictures, and this gives the impression of relief or of being raised or solid.

To make use of a stereoscope, that is an instrument which gives to a picture on a flat surface the appearance of being in relief, it is necessary to take two impressions of the picture so that each impression represents the object to each eye as the solid object itself would.

One of the first stereoscopes given to the public was that invented by Wheatstone. This instrument is contained in a rectangular box. Two views of the same object,

represented according to the principles of stereoscopic vision, are placed in grooved slides, one at each side of the box ;[1] two small mirrors are fixed at right angles to one another in the centre of the box ; the eyes of the

Fig. 66.



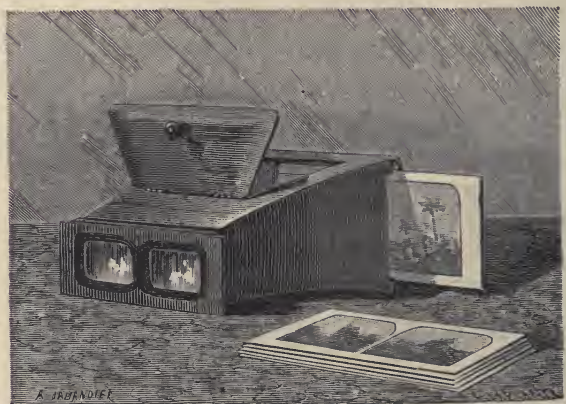
observer, being situated a little in front of the mirrors, will see the pictures at the sides reflected from them, and when the eyes are at the proper distance, the two

[1] It is not generally known that in taking a photo-micrograph of minute invisible crystals, or of any microscopic preparation standing out in relief, in order to obtain a perfect stereoscopic photograph of the object, neither the camera nor the preparation need be moved. The stereoscopic relief may be obtained by first taking a picture with the light on one side, and then taking a second picture with the light on the other side of the object.—ED.

pictures as reflected and viewed through lenses will appear as one, and in relief.

Brewster's stereoscope (fig. 67), and that of Heimholtz (fig. 68), are on somewhat different principles, and are considered to be improvements on Wheatstone's. Every

Fig. 67.



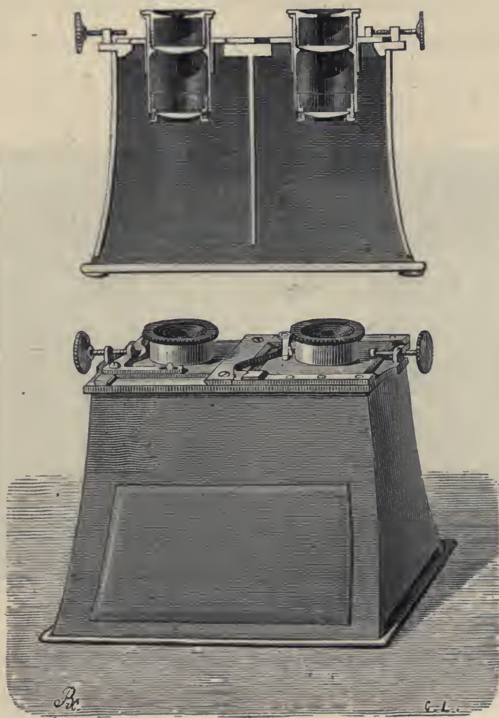
BREWSTER'S STEREOSCOPE.

one has looked at photographs through such instruments; their management is too simple and their use too common to require us to spend any time in describing them.

The stereoscope was invented at about the same time as the daguerreotype. At first it was used for the purpose of viewing pictures drawn by the hand, but on

the discovery of photography the two new arts lent each other mutual support ; they became so intimately con-

Fig. 68.



HEIMHOLTZ'S STEREOSCOPE.

nected that now the stereoscope and the photograph appear to be almost two parts of the same instrument.

In 1858 an able operator, M. Claudet, invented a very curious kind of stereoscope which can be seen by several people at the same time. This instrument consists of a dark screen the centre of which has been cut out and the space occupied by a piece of ground glass; by means of two magic lanterns, two images of the

Fig. 69.

MONO-STEREOSCOPIC PRINT.

same object are thrown upon this, and are so combined as to give the impression of the picture being in relief, without the necessity of viewing it through any optical instrument (fig. 69).[1]

[1] This method of combining stereoscopic pictures is not so successful as to command extensive application.—ED.

The facility of procuring by means of photography views so delicately printed by Nature herself has singularly contributed to the perfecting of the stereo-

Fig. 70.

FEVRIER'S PILLAR STEREOSCOPE.

scope, which is now manufactured with admirable correctness.

After Brewster's stereoscope, the Pillar Stereoscope (fig. 70), invented by M. Fevrier, gives to photographs

such an appearance of relief, and so enlarges them, that nothing can better represent natural objects.

In this apparatus, with the eyes fixed upon the lenses, by turning a small button causing the rotation of an axis, around which the stereoscopic photographs are arranged, Switzerland, the Pyrenees, China, Japan, come one after the other under the view of the observer, who can admire, without stirring from his chair, distant places, even those most inaccessible to the traveller.

We now come to the processes employed in producing photographic impressions suitable for being viewed through the lenses of the stereoscope.

The photographic picture should be double, that is to say, it is necessary to take two views of the same subject ; these two views ought to be identical in their central parts, but differ a little at their sides. To attain this result a first view is taken of the object by placing the photographic camera towards the right, and then a second view is taken after moving it a little to the left.

To give greater correctness to the impressions two views are generally taken at the same time by two distinct cameras, having lenses of uniform focus, fastened together by a movable slide fixed on the top of a tripod.

If it be wished to take two stereoscopic pictures of

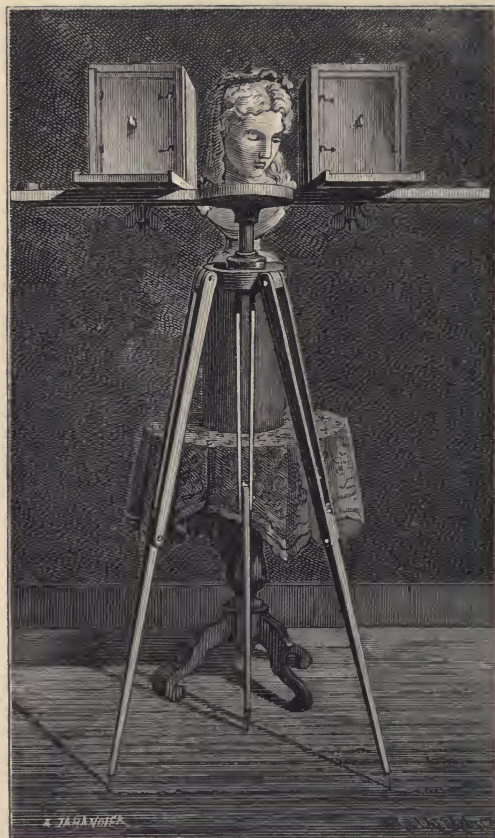


FIG. 71 [Page 295

APPARATUS FOR OBTAINING THE TWO PROOFS OF THE STEREOSCOPE.

an object, such as a picture or a statue, the two cameras are placed at about the distance of ten feet from the model, and are separated from each other by about six inches. Care must be taken before introducing the collodionised glass into the cameras that the inclination of the two images in the foci of the cameras is such as will produce the desired effect. For this purpose it must be ascertained that the point of the object which is in the centre of the ground glass of the camera to the right be also exactly in the centre of the ground glass of that to the left. This fundamental observation being once made, the photographs are taken in the ordinary manner. The apparatus ready for use is represented in figure 71. Figure 73 gives the facsimile of a stereoscopic slide formed of two photographic views placed

Fig. 72.

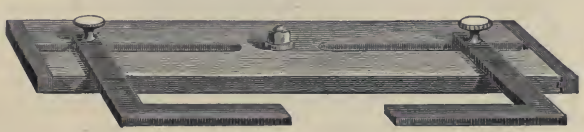


PLATE FOR SUPPORTING THE CAMERA WHEN TAKING STEREOSCOPIC VIEW.

beside one another under the conditions suitable for stereoscopic vision.

It is a good plan to print the positives for the stereoscope upon glass; the transparency of the glass lights

up the picture better and helps to give it relief and solidity.[1]

When it is wished to take stereoscopic views of landscapes, buildings, or of distant objects in general, only one view is taken at a time with one camera. This camera rests upon a plate on which it moves easily from right to left guided by two squares which move in a groove as seen in fig. 72. A first view of the subject is taken by placing the camera at the right side of the plate, carefully observing the object which is in the centre of the ground glass of the camera. This view having been taken, the camera is moved to the left of the plate and carefully adjusted so that the same object is again in the centre of the ground glass, though the lens has changed its position ; a second view is then taken. The two positions occupied by the camera are separated by about three inches, a distance which nearly corresponds with that of the pupils of the human eyes.

[1] The position of the two pictures taken in this way must be reversed when printed and mounted on card.—ED.

FIG. 73

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FAC-SIMILE OF A STEREOSCOPIC PHOTOGRAPH.

CHAPTER X.

PHOTOGRAPHY AND ART.

IS PHOTOGRAPHY ART?—ITS USES IN RELATION TO PAINTING REPRODUCTION OF ENGRAVINGS—VOYAGES OF DISCOVERY—PHOTOGRAPHY BY THE MAGNESIUM LIGHT—PHOTOGRAPHIC PORTRAITS CONSIDERED AS HISTORICAL DOCUMENTS.

PAINTERS are not generally carried away by their admiration of photography; its physico-chemical processes seem incompatible with the sentiments which animate them; they feel repugnance in placing collodion beside a palette of oil colours. Many, indeed, are very severe upon the art of Daguerre; there are some who cannot hear a photographic print praised without feeling much annoyed.

Photography, they say, composes nothing; it only gives a copy, a mere imitation, brutal in its truth. It wants sentiment, no flame of genius gives it life. It is awkward, it gives an equal value to important parts and to accidental details.

If it takes a portrait it copies its model unskilfully; it represents the ornaments of a dress better than it can

give the expression of a face ; the eye of the sitter is not given better than the button of his sleeves ; photography is mere mechanism, it is not art.

To produce a good negative, say the photographers, on the other hand, it is necessary to study the subject as well as to select and combine the effects of light ; and this needs the intervention of artistic sentiment. The first negative obtained, says a distinguished practitioner of the art, the work is only sketched out. Light is an uncertain instrument which is never under complete control. It is necessary that the photographer, appreciating its defects and its merits, should palliate the one and bring out the other more prominently. It is then, adds our apologist, that the photographer shows himself to be an artist in the full acceptation of the word ; that he causes his mind and his genius, if he have genius, to pass into the print ; that he gives it colour and that admirable completeness, as well as those effects which impress and take hold of the mind in as lively a manner when admiring certain photographic portraits or landscapes as when in presence of a canvas of Ruysdael or of Titian.

In a series of photographs, says an eminent scientific writer, we meet by turns a Van Dyk and a Delaroche, a Reynolds and a Turner, a Titian and a Scheffer, a

Ruysdael and a Corot, a Claude Lorraine and a Marilhat.

These views are evidently exaggerated on both sides. Let us try and give a just and reasonable opinion, avoiding the two rocks of systematic disparagement and of too enthusiastic admiration.

Certainly photography has serious disadvantages. The instrument which acts has not the powers of the artistic hand, which is guided by the love of the beautiful and just impressions of the effects of nature. It often injures the linear as well as the aerial perspective ; the process of developing the image not unfrequently reproduces the distances as distinctly as the foregrounds ; while the shadows in some photographs form dark blots, flat and heavy tones, which deprive the picture of all grace and harmony. Especially is this the case if the instrument is guided by an inexperienced hand.

But it cannot be denied that the photographic apparatus, if managed by the hand of an operator having at the same time the skill of a proficient and the taste of the painter, produces pictures marked with the seal of art.

We see every day issue from the studios of the masters of the art a great number of admirable photographs : they have colour, relief, delicacy, and truth ;

some of them even can rival the most beautiful sepia drawings, or the finest miniatures. If, on the other hand, there are bad photographs, it must be admitted that some shocking bad pictures exist.

We shall not enter further into this order of ideas and discussions. It is dangerous, in our opinion, to wish to establish a parallel between painting and photography, which differ essentially in their processes and mode of production. At the same time it appears to us to be exceedingly unjust to deny to photography the rank of one of the fine arts.

It constitutes, doubtless, a true and a great art; but we shall quit this slippery ground for the purpose of broaching a much more interesting question, that of the services which photography is capable of rendering to all artists—to the painter, to the sculptor, to the architect.

The illustrious Paul Delaroche, soon after the invention of the daguerreotype, did not fear to say, in presence of the members of the Academy of Science, the daguerreotype carries to such perfection certain essential points of art that it must become an object of study and observation to the greatest painters. Paul Delaroche spoke the truth. A collection of photographs is indeed an inexhaustible source of useful information for

the artist. It is certain that no painter at this day, whatever may be his talent, will attempt to paint a portrait without having good photographic likenesses of his sitter. It is also evident that a landscape painter cannot be too well acquainted with those admirable studies of nature which true artists have placed upon the collodionised glass. The student will also find valuable examples in those fine photographs which reproduce the magnificent cartoons of the Louvre—unique sketches, the produce of the magic crayon of Raphael, or the pencil of Michael Angelo. No one would be bold enough to attempt to reproduce the designs of these great masters by the burin of the engraver, or by the pen of the lithographer. Photography performs the miracle of multiplying to infinity an etching of Correggio or of Titian.

Again, what resources in the hands of an architect, or an archæologist, are the views of buildings in distant countries! The marvels of Athens and of Rome, the inimitable richness of the monuments of India, the bold architecture of Egyptian temples, can be kept in his portfolio, not modified and disfigured by an untrustworthy pencil, but such as they are in reality with their beauties, their imperfections, and the marks of destruction which time has engraved upon them. Photographic

prints are mirrors from which are reflected the banks of the Nile and of the Indus—the buildings and the landscapes of all the countries through which the camera has passed.

The explorer furnished with his photographic apparatus, which is now constructed in such a manner that it can be used with ease in any part of the world (fig. 74), brings back with him from his travels documents invaluable, because no one can deny their accuracy. A photograph represents an object just as it is—the landscape as nature has formed it—the building as it has been seen, a broken column, a mark upon a stone. Nothing is deficient in the print. A painting or a watercolour can never have such rigorous precision. The artist is often tempted to omit some object which appears to injure the effect of the whole, or to add some ornament to his work.

Finally, in certain cases, photography is able to reproduce by the aid of artificial light the representation of masterpieces of art or of natural beauties which may be buried in darkness. In a great number of subterranean chambers, hollowed out under the ancient temples of Egypt, the walls are covered with paintings and hieroglyphs which the savant cannot study with advantage during a short visit. The photographer, by means of the magnesium light, takes the exact transcript of these in-

FIG. 74

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PHOTOGRAPHY AND EXPLORATION.

scriptions, or of these figures ; he puts in the hands of the archæologist a faithful copy on which he can study, by the aid of a magnifying glass, the most minute details. The mode of operating most frequently practised in Egypt is

Fig. 75.

PHOTOGRAPHY BY THE MAGNESIUM LIGHT IN THE CATACOMBS.

identical with that employed in taking photographic views of certain curious parts of the catacombs of Paris. (Fig. 75.)

The applications of photography to art are innumerable, and the future will produce many results of the extent of which we cannot now give an idea.

The carbon process of photographic printing, only recently discovered, will soon produce, if it has not already succeeded in producing, unchangeable prints as durable as the impressions of typography; it will thus perpetuate in history the appearance of the great men who have played their part in the changes of modern society. What incomparable value would now be attached to photographs of the great writers of the age of Louis XIV., or of the philosophers of the eighteenth century! What profound emotion would not one feel in contemplating the truthful images of the men of genius who have enlightened humanity!

Our descendants will assuredly enjoy such surprises and many more, which the most clear-sighted cannot foresee.

All that we can affirm is, that if the uses of photography are now almost innumerable, they will certainly still go on increasing to an unknown extent. However marvellous the results already obtained may be, they will be improved so as to reach such a summit of perfection as our mental eye cannot perceive through the dense mist which veils from us the image of the future. We have seen the efforts made by Becquerel and Niepce de Saint-Victor to obtain photographs with the colours of nature. The problem of coloured photo-

graphy is not insoluble. It will be solved one day. Then the art will march along a new course wonderfully fruitful in such results.

It is often imprudent, and even undesirable, to attempt to look too closely into the future, but in some cases it is possible to do so without exceeding too much the limits of reason. In such cases it is necessary to rest upon facts, and not give too much play to the imagination. We have studied the past of photography ; we have admired the marvels we owe to it in the present ; will the reader pardon us if we now endeavour to dive a little into the future ?

CHAPTER XI.

THE FUTURE OF PHOTOGRAPHY.

LAND-SURVEYING—THE ART OF WAR—WORKS OF ART—CRIMINALS AND JUDICIAL PHOTOGRAPHY—THE MIRACLES OF INSTANTANEOUS PHOTOGRAPHY.

IF we would fathom the depths of the future while restraining ourselves at the same time within the limits of common sense, we must carefully examine the ground over which we would extend our view. We shall first examine what has been done up to this time in utilising photography in the art of taking plans, and then we shall be able to perceive the resources it will afford during war.

A retired military surgeon, M. Auguste Chevalier, has already considered it possible to combine surveying with photography. He places a camera on a land-surveyor's stand, fixing it upon an axis so that it can be turned round in any direction. By directing the lens of the camera to the different points of the horizon pictures of each part are obtained, the whole forming a complete

FIG. 76

THE POLÉMOSCOPE.

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panorama which must be absolutely correct ; from this a plan or map of the country can be drawn by means of certain operations, the details of which are too technical for us to enter into.

In 1859, during the war in Italy, some military engineer officers, no doubt thinking of the polémoscope reflecting images by means of mirrors (fig. 76), a kind of forerunner of the employment of the camera, made use of the photographic plate. The experiments they made allowed them to form some idea of the advantages of this new branch of photography, though they did not thoroughly master it. No doubt in the future, the camera will supply valuable assistance to the military art.

The application of photography to taking military plans and panoramic views, in the opinion of competent judges, is on the eve of being completely realised. When this new application is perfected, science will again be distinguished by considerable progress. We cannot over-estimate the great services the camera ought to render in this kind of work.

No longer any want of correctness in producing the plan, no minute calculation, no difficulty, no annoyance. The picture of the country will be taken, the map will be completed, without, so to say, giving it a thought. In time of war, a general will have photographs of the

field of battle—of the fortresses he would besiege, and should any point of the horizon be concealed from him, the camera thrown into the car of a balloon held captive by a cord, and thus rising above woods and hills, will take a faithful impression of all within its view.

Narrators of fairy tales and other extravagant stories have often put into the hands of their heroes magic mirrors, wonderful talismans, which suddenly reflect the images of distant objects. Photography realises the conceptions of the imagination of the poet. We remember being present at a singular scene, which we shall endeavour to describe.

One of our friends, a military engineer, engaged in superintending some railway works, was addressing some words of blame to the contractor who was employed in building a bridge. He complained of certain faults of construction, and especially at the slow progress of the work.

'But I beg your pardon,' replied the contractor. 'Are you quite sure your information is correct, for you have not personally visited the works?'

'I have not stirred from home, it is true,' replied the engineer; 'but here is a mirror which is sent to me regularly, and which tells me every week what quantity of stones you have collected, what number of bars of

iron you have got together.' He then took from his drawer some photographs.

'I employ a photographer,' he continued, 'who sends me every morning a picture of your work taken on the spot. Here is the complete series. The moving crane, which a fortnight ago was three yards from the second pile and which advanced five yards the preceding week, has moved very slowly for the last eight days. It is necessary, I tell you, to be more active. All that you do there, I see here; the photographs which are sent to me give me even the appearance of your workmen, and if one of them has been idling while the picture was being taken, I can take him to task from my office here.'

I listened to this singular conversation, and I said to myself, that the future would work out more perfectly this system already made use of. The day may perhaps come when the negative will be taken at a distance by means of the electric wire; and if some reader exclaims, Impossible! I shall refer him to certain telegraphic systems lately discovered, which allow us to anticipate this new miracle.[1]

Not less wonderful is the arrest of criminals by

[1] I believe that there is nothing Utopian in the notion that, ere long, means will be discovered of telegraphing a photograph from one end of the earth to the other; a most desirable consummation for the Metropolitan Police, and for the 'Illustrated London News' and 'Graphic.'—ED.

means of their photographs. Here are some accounts of what has been done in England, of a nature to show us the resources of judicial photography.

It appears from a report on photographing criminals in London that from the 20th November 1871, to the 31st December 1872, 375 arrests took place in England in consequence of the identity of criminals having been proved by means of their photographic portraits. During this time there had been received from county and borough prisons at the Habitual Criminals Office 30,463 portraits of criminals. This shows that the practice of taking the portraits of malefactors by means of photography is useful, and at the same time we may mention it does not cost much, since the portraits of all the prisoners of the 115 prisons of England and Wales, from the time that the Act of 1870 came into operation to the 31st December 1873, only cost 2,948*l.* 18*s.* 3*d.* Perhaps it might be desired, in order to make the services it renders more practical, that the criminal portrait gallery should be open to the public. It would thus be possible to make the arrest of malefactors, upon whom the police are unable to lay their hands, more easy. It would be the same with dead bodies which had not been claimed by anyone. We do not doubt that means would thus be

found for the arrest of murderers, whose names, as well as those of their victims, remain unknown.

It is again from the foreigner, and this time from the United States, that we take some accounts, still more singular perhaps, of the uses to which the art of Daguerre may be put.

An eye-witness from the other side of the Atlantic, who was present at some of the riotous scenes of the last elections, assured us that an American photographer had succeeded in taking an instantaneous picture of a public meeting in the open air. He had suddenly fixed in the focus of the camera the orator who was gesticulating from the top of a temporary hustings, the group of listeners who were raising and waving their arms, some showing marks of approbation and approval, others with signs of impatience and anger. This photograph was immediately taken to his studio, for the purpose of converting the negative into a plate to be printed from by the heliographic process. If he had succeeded, that very evening there might have been distributed 100,000 copies of the photograph, printed in an ordinary printing press. He failed, but others will accomplish this wonder of producing upon collodion such animated scenes, in depicting in a permanent form man in action, an agitated crowd, an army

in battle, the orator as he speaks, the wave as it foams, or the meteor which traces its luminous track through the azure of heaven.

We could still recount the resources which the art of the land-surveyor—geography, history, every branch of science as well as all the conceptions of human learning — will one day find in photography; but the reader, after having acquired the knowledge of the actual powers of the wonderful invention of modern times which is the subject of this volume, will himself know how to look for the future applications which are logically derived from those actually practised. Instantaneous photography, the heliograph, photography naturally coloured by the light itself, will be the most fruitful branches of the tree planted by Niepce and Daguerre — their buds have scarcely yet burst from the stem, but they already appear, and no one can say to what heights they may reach.

*** *In the Appendix the reader will find some formulæ of the various solutions &c. employed in the Wet Plate and Dry Plate Processes and for obtaining paper proofs. Also some other matters of interest which it was difficult to give in the body of the work.*

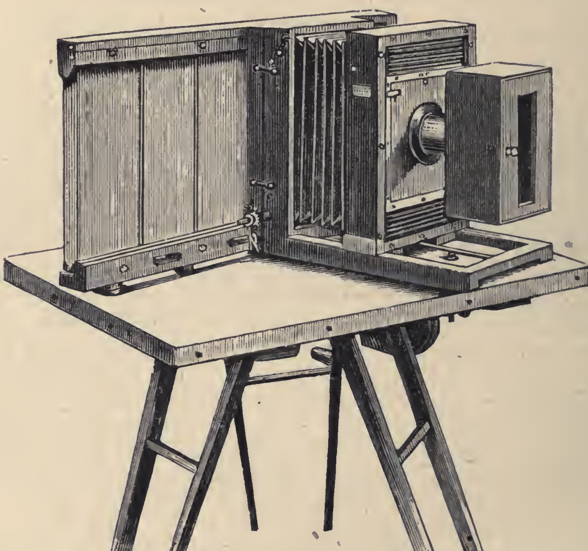
APPENDIX.

PANORAMIC PHOTOGRAPHY.

If a photographic camera is turned round upon its optical centre the image of an object will appear to move to one side on the ground glass. In reality the image remains stationary while the ground glass is in motion. Rotating cameras based on this principle have been constructed at various times. One of the best was that invented by Mr. Johnson, and called the Pantascopic Camera; but this instrument was only fitted with a single lens of short focus, so that the horizontal lines of the picture were always slightly curved. For large apparatus of this kind the clockwork by means of which the horizontal motion is obtained cannot be made cheaply and accurately, and at best it is easily deranged, and can only be repaired by a skilful mechanician, and such would certainly not be found in regions where the finest scenery abounds. The large angle of view obtainable by the rotating camera, only limited by the length of the dark slide, rendered it desirable to introduce a simple instrument, not easily deranged, that could be adapted to any single, double, or triple lens, suitable alike for groups and landscapes, and capable of producing negatives equal to those taken with the best stationary cameras now in use.

It appears that M. Liesegang, of Düsseldorf on the Rhine, has constructed a simple rotating camera which was employed by M. Schultz, of Dorpat, in taking the beautiful groups awarded a prize medal at last year's Paris Exhibition. The bridges and views taken by M. Schoenscheidt, of Cologne, as well as the work of many English, Italian, and Indian photographers, prove the success of the invention. M. Liesegang uses a stand nearly of the common tripod form, but stronger and more stable. This stand carries a large polished table supplied with a pivot or axis on which the camera turns. The pivot is so adjusted as to fall into the same plane as the optical centre of the lens.

The camera is half as broad as it is high, and has a slit through which the rays of light pass which form the image, the opening of the slit being not more than a quarter of an inch wide, a little wider only where the near foreground falls, in order to secure a longer exposure for that portion of the picture, and thus impart greater uniformity to the tone of the negative. The dark slide when in the camera is closed around by a flexible band, the slit only being left open.



PANORAMIC CAMERA.

The two motions of the instrument, viz. that of the frame containing the prepared plate, from right to left, and the motion of the camera on its axis, are managed by a simple arrangement of horizontal cords and pulleys. The operator, after focussing, has only to turn a handle to take in the wide scope of the horizon, or a group of friends ranged in a semicircle round the instrument. The other operations are the same as in the ordinary camera.

THE HELIOTYPE PROCESS.

The Heliotype process, as worked by the Licensees of the Heliotype Company at their works at Kilburn, is based upon another method of utilising the action of light upon gelatine rendered sensitive by the admixture of bichromate of potash. It is in effect a development of the Albert-type process, wherein the gelatine itself forms no part of the picture, as in the Woodbury-type, but is simply used as a printing surface. In the Heliotype process the gelatine is dissolved in warm water, and a sufficient quantity of bichromate of potash is added to make it sensitive to light, together with a certain proportion of chrome alum, to render it very hard and durable. This solution is poured, while hot, upon a glass plate previously waxed; the film, when dry, is stripped off, and exposed to light under a reversed negative. Having thus received the photographic image, the film is made to adhere to a metal plate, the superfluous chemicals are soaked out in water, and the plate, bearing the printed surface of gelatine, is placed on an ordinary printing press, inked with lithographic ink, and the proofs are pulled, on either plain or enamelled paper, in the ordinary way, the plate being damped with water after each impression. The greasy ink readily adheres to the deep shadows, which, being hard, insoluble, and non-absorbent, have repelled the water altogether; the 'high lights,' on the contrary, having freely absorbed the water, repel the ink, and are left perfectly white; while the parts representing intermediate gradations of tone retain the ink in such degree as they have repelled the water. This graduated or discriminative power of absorption renders the mechanically-printed image a perfect transcript of the negative. The ink used may either be of a photographic tone, in which case the impressions when varnished bear a close resemblance to silver-prints; or it may be of any colour or tint desired, to ensure a close resemblance to any work of art that is being copied. Clean margins are obtained by the use of a 'mask' of thin paper, and thus the necessity of 'mounting'—so objectionable when the prints are to be used as book illustrations—is avoided. Surprise has often been expressed at the possibility of an organic substance such as gelatine being made to withstand the wear and tear of mechanical printing. But by the addition of chrome alum it is converted into a substance resembling horn, and as a matter of fact several thousand impressions have been obtained from a single film. The effect of an India or other coloured tint is obtained by using, instead of clear water for damping the plate, water with a small quantity of some dye in it. The Heliotype process, though for some purposes inferior to the Woodbury-type, offers special advantages for book-illustration, and has been adopted with success in many artistic

and scientific works of importance. One of the strong points of this process is the fidelity with which the character of the original is preserved, the appearance of 'glaze,' common to all silver prints on albumenised paper, and inevitable also in Woodbury-type prints, being entirely absent in the Heliotype.

THE PHOTO-TINT PROCESS.

This process, recently perfected by Mr. B. J. Edwards, is also in use at the same works as the above. It is more simple than the Heliotype, and while adding to the rapidity and certainty with which the prints are produced, it gives finer and more delicate results. The frontispiece to this work is printed by the photo tint process.

EPITOME OF THE WET COLLODION PROCESS AND USEFUL FORMULÆ.

Negatives should be taken either on polished flat crown glass, free from specks and scratches, or on patent plate glass. It is false economy to employ glass of inferior quality, as what might at first appear only a trifling imperfection in the plate is apt to spoil the finest negative, or to cause breakage in the printing frame.

The glass plate ought to be chemically clean [1] when prepared to receive the collodion. It must indeed be borne in mind as a sort of maxim that

[1] As it is often necessary to make use of old plates which it is a difficult matter to get perfectly clean, and unless they are clean a prolonged development of the image will often bring up stains on them, the following simple plan may be adopted: First, well wash the plates in water containing a very small quantity of muriatic acid; rinse in plain water; now coat the plates (which after drying must be carefully brushed wtih a badger-hair brush to remove any particles of dust) with a quantity sufficient to cover the plate of a mixture made as follows, and used fresh:—

To 2 quarts of water add 7 drops of ammonia
7 drops of acetic acid
The white of one egg
Well shake and filter.

This mixture is used exactly as when coating the plate with collodion, except that any surplus is not returned to the bottle, but thrown away. The plates thus coated are dried in a drying rack away from dust, and when dry may be used at any time for receiving the collodion in the ordinary way. Plates thus prepared do not readily develop stains or show scratches, and are said to keep longer without drying in hot weather; a great aid to the landscape photographer.

cleanliness of manipulation and methodical care are the chief attributes of the successful photographer.

The plate is first coated with iodised collodion (see p. 109). Suitable negative collodion and iodising solution may be procured in separate bottles, supplied with printed directions, from any photographic dealer.

SENSITISING BATH.

The nitrate of silver bath is next used for immersing the collodionised plate, and may be prepared in the following proportions:—

Nitrate of Silver	1 ounce.
Distilled Water	15 ounces.

Before using the bath coat a plate with iodised collodion, and allow it to remain in the solution for four or five hours. After this plate has been withdrawn test the bath with a piece of blue litmus paper; should the paper slowly change its colour to red, the solution may be filtered through blotting paper and used. But should the test paper remain unaltered in colour, add one or two drops of nitric acid to the bath, so as to render the solution slightly acid before use.

DARK ROOM OPERATIONS.

When a collodionised plate has been immersed in the sensitising bath long enough to get quit of the greasy appearance on its surface, it may be removed, placed in the dark slide and exposed in the camera. The operator must use his own judgment in determining the duration of exposure. With a good portrait lens in a favourable light it will vary from one to ten seconds. The plate after exposure in the camera must be brought back to the dark room and developed.

1st Developing solution:—

Protosulphite of Iron	20 grains.
Glacial Acetic Acid	20 minims (or drops).
Alcohol	30 minims.
Water	1 ounce.

Or,

Ammonio-sulphite of Iron . .	20 grains.
Glacial Acetic Acid . . .	20 minims.
Alcohol	30 minims.
Water	1 ounce.

Either of the above solutions may be employed successfully by the beginner, but the proportions may be varied to such an extent as to enable almost every photographer to use his own favourite developer.

When the first solution has been washed off, the re-developing or intensifying mixture may be applied in quantity sufficient to flood the plate:—

Pyrogallic Acid	3 grains.
Citric Acid	3 grains.
Water	1 ounce.

To this must be added, just before using, two or three drops of a solution of nitrate of silver:—

Nitrate of Silver	30 grains.
Water	1 ounce.

The action of the re-developer must be carefully watched by the light of the yellow window in the dark room, and arrested when the high lights of the picture have acquired the proper intensity.

FIXING.

Wash off the intensifier and consign the plate either to a bath containing a nearly saturated solution of hyposulphite of soda, or pour over its surface a weak solution of cyanide of potassium (100 grains to 10 ounces of water). In any case the negative, after it has been cleared of the yellow iodide of silver, must be thoroughly washed to remove all trace of the fixing agent. It is then dried and varnished.

The negative varnish, which may be had from any photographic chemist, is applied in the same way as collodion, but the plate must be first slightly heated. The operator cannot go far wrong in following the printed directions on the bottle.

POSITIVE SILVER-PRINTING FORMULÆ.

As the various operations connected with positive printing are described in these pages, it is needless to do more here than to supply useful formulæ for ready reference.

Sensitising bath for albumenised paper:—

Nitrate of Silver	60 grains.
Water	1 ounce.

Toning solution:—

Chloride of Gold	1 grain.
Bicarbonate of Soda . . .	4 grains.
Water	6 ounces.

The toning solution may be used two or three minutes after it has been made.

Fixing solution:—

Hyposulphate of Soda . . .	4 ounces.
Water	1 pint.

The toned prints, after they have remained from fifteen to twenty minutes in the fixing solution, may be removed and thoroughly washed in repeated changes of water, and allowed to soak for twelve hours, when they may be dried, cut, and mounted.

Sago, well boiled and strained through muslin, makes an excellent mounting paste.

SIMPLE METHOD OF PREPARING DRY PLATES.

By the kind permission of Canon Beechy and the Editor we are able to print the following interesting and useful extract from 'THE BRITISH JOURNAL OF PHOTOGRAPHY,' No. 804, Vol. XXII., October 1, 1875.

1. Always have in stock the following articles:—

Absolute Ether	1 pint.
Absolute Alcohol	1 ,,
Alcohol ·820	1 ,,
Hydrochloric Acid	1 ,,

(The latter is as useful in cleaning the plates for albumenising as for the emulsion.)

Gun Cotton of suitable quality, at least . .	1 ounce.
Bromide of Cadmium	1 ,,
Pyrogallic Acid	1 ,,
Fused Nitrate of Silver in powder . . .	1 ,,

The above constitute all the chemicals employed in the manufacture of these plates.

2. Have also in stoc', ready for use at any moment (*a*), at least two dozen properly albumenised plates, and (*b*) a stock bottle—say eight ounces—of the following bromide solution :—In eight ounces of absolute alcohol dissolve five drachms of anhydrous bromide of cadmium. The solution will be milky. Let it stand at least twenty-four hours, or until perfectly clear. It will deposit a white powder. Decant it carefully into an eight-ounce vial, and add to it one drachm of strong hydrochloric acid. Label it 'bromide solution.' It is as well to add on the label the constituents, which will now be found to be *nearly*—

Alcohol	1 ounce.
Bromide of Cadmium	32 grains.
Hydrochloric Acid	8 drops.

This solution will keep for ever, and be sufficient to last the amateur two or three years. With it at hand he is now able in two days to prepare a batch of plates at any time. In doing so he wi l proceed thus :—

3. Settle how many plates you mean to make and take of the above accordingly. For two dozen half-plates ($6\frac{1}{2} \times 4\frac{3}{4}$) (*a*) dissolve by heat over (but not too near) a spirit lamp, and by a yellow light,[1] forty grains of nitrate of silver in one ounce of alcohol ·820. Whilst this is dissolving in a little Florence flask, on a retort stand at a safe distance from the lamp (which it will do in about five minutes), take of the—

(*b*) Bromised Solution	½ ounce.
Absolute Ether	1 ,,
Gun Cotton	12 grs

Put these into a clean bottle, shake once or twice, and the gun cotton, if good, will entirely dissolve. As soon as the silver is *all* dissolved, and whilst quite hot, pour out the above bromised collodion into a clean four-ounce measure, having ready in it a clean slip of glass. Pour into it the hot solution of nitrate of silver in a continuous stream, stirring rapidly all the while with the glass rod. The result will be a perfectly smooth emulsion without lumps or deposit, containing, with sufficient exactitude for all practical purposes, eight grains of bromide, sixteen grains of nitrate of silver, and two drops of hydrochloric acid per ounce. Put this into your stock emulsion bottle and keep it in a dark place at least twenty-four hours. When first put in it will be *milky*; when taken out it will be *creamy*. It is well to shake it once or twice in the course of the twenty-four hours; but do not always do so.

4. At the end of twenty-four hours you can make your two dozen half-plates in little more than an hour. Proceed as follows :—Have two porcelain dishes large enough to hold six (or four, *at least*) of your plates. Into one put sufficient clean, filtered rain water to nearly fill it. Into the other put thirty ounces (a pint and a-half) of clear, flat (not acid) table beer, in which you have dissolved thirty grains of pyrogallic acid. I rea ly do not know a simpler or more satisfactory preservative than the above. I like to use bitter beer at one shilling per gallon. The pyro. dissolves in it at once. Pour it through a filter into the dish, the neck of the funnel being within half-an-inch of the bottom, to avoid bubbles. If allowed to let stand an hour any beer will be flat enough. If the beer be at all *brisk* it will be difficult to avoid little bubbles on the plates. At all events, let your preservative stand whilst you filter your emu'sion. This must be done through cotton-wool into a perfectly clean collodion bottle. Give the emulsion a good shaking, and when all bubbles have subsided pour it into the funnel and it will all go through in five minutes.

The filtered emulsion will be found to be a soft, smooth, creamy fluid, flowing easily and equally over the plates. Coat with it six plates in succession (if your dishes will hold six), and place each as you coat it in the water. By the time the sixth is in the first will be ready to come out. Take it out, see that all greasiness is gone, and place it in the preservative. Coat another plate and put it in the water where the first came out. Remove your second plate from the water into the preservative, and in its place lay another freshly coated plate, and so on until the first six are all in the preservative and six more in the water. You now take the first plate out of the preservative into your drying-box, and again remove the first out of the water into the vacant place in the preservative. Coat another and put it into the vacant place in the water. Take your second plate out of the preservative into the drying-box and the second out of the water into the preservative,

[1] If ordinary bromide be used, thirty-two grains of silver will be sufficient.

and so on till all your plates are through the process and locked up safely in the drying-box. By proceeding as above not a moment of time is lost, and yet each plate soaks sufficiently in the water and in the preservative. You will find an hour, if you are dexterous, sufficient time for two dozen plates.

As it is my wish to render this process so practical and simple that amateurs may make their own plates, the following particulars as to material, exposure, and development will not be *de trop*:—

1. As to materials: I recommend all to be got from some eminent photographic chemist. There are many such: in every large town at least one. I obtained my pyroxyline from Mr. Rouch, of Norfolk-street, who also made my drying-box from my instructions, than which nothing can work better. It holds twenty-four half-plates, has a sheet-iron bottom, with air-tubes supplying hot, fresh air between every two plates. I generally make my plates at night, and when they are all in the rack and locked up I light a spirit lamp containing one ounce of methylated spirit, under the drying-box, and go to bed. In the morning I may pack up my plates and set out on my expedition, confident that I have two dozen reliable dry plates.

2. As to exposure: these plates do not profess to be *very* rapid, but they are sufficiently so for every ordinary purpose. From thirty to sixty seconds according to light will be enough, but they will do with less and bear strong ammonia development without fogging; or they will do with more, the development being stopped sooner. Unless you take with you the means of developing it is better to try a plate before you start. In spite of every precaution there will somehow be a difference in a batch of plates now and then. I may mention, also, that I never back my plates, for the reason that I never find they require it. They will not blur with any light that will not also blur backed plates.

3. For developing I use Colonel Wortley's strong developer. I mean the one published with his excellent rapid uranium plates, which I copy:—

A.	Pyrogallic Acid	96 grains.
	Alcohol	1 ounce.
B.	Bromide of Potash	12 grains.
	Water	1 ounce.
C.	Carbonate of Ammonia	64 grains.
	Hot Water	1 ounce.

By all means use *carbonate* of ammonia. The liquid ammonia often destroys a good negative, and always gives a more inky picture. For a half-plate take of A thirty drops, of B sixty drops, of C two drachms, or even three if the exposure be short. I never use any alcohol, but simply wet the plate well under the tap, thereby washing off the beer, and pour on the developer. The picture will come out in a few seconds. On its first appearance pour back the developer into the measure and let the picture come out of itself. You will be surprised to see how it *will* come out. You can then judge as to exposure and proceed according'y, adding bromide if too rapid, or pouring on the developer as it was if all right, or with an extra thirty drops of C if under-exposed. These plates seldom require to be intensified. If they do the ordinary acid silver and pyro. redeveloper will bring them up easily and at once. Clear with either hypo. or cyanide as you please, and if you intensify do it after clearing; but the beer gives these plates a bottle-green tint, which is more impervious to actinic light than from its transparency you wou'd suppose.

These p'ates are more rapid if placed at once in the preservative without washing; but they require to stay in till all greasiness has disappeared, and I doubt if they keep as well or are so certain. To wash first is safest for amateurs.

In conclusion: I am glad you have asked me for the above formulæ, since I have had more letters enquiring for them than I could find time to answer. I claim nothing new in the process but the beer and pyro. preservative. You know I am a pupil of Colonel Wortley, and my process is essentially his applied to a humbler and more domestic class of plates. I have tried to simplify their preparation for amateurs, and I am quite sure ninety-nine out of a hundred will prefer them to the host of complications which from time to time 'go up like a rocket and come down like a stick.'

WEIGHTS AND MEASURES.

ENGLISH.

Troy Weight.

20 Grains	=	1 Scruple. ℈.
3 Scruples	=	1 Drachm. ʒ.
8 Drachms	=	1 Ounce. ℥.
12 Ounces	=	1 Pound. ℔.

480·0 Grains Troy	=	1 Oz. Troy.
437·5 ,, ,,	=	1 Oz. Avoirdupois.
7000·0 ,, ,,	=	1 Pound ,,
5760·0 ,, ,,	=	1 Pound Troy.

1 Minim (or drop)	=	1 Minim.
60 Minims	=	1 Fluid Drachm. f ʒ.
8 Fluid Drachms	=	1 Fluid Oz. f ℥.
20 Fluid Ounces	=	1 Pint, *octarius.*
8 Pints	=	1 Gallon, *congius.*

FRENCH.

The French Kilogramme (= to about 2 lbs. 3 oz. 4½ drachms Avoirdupois) is the weight of a cubic decimetre of distilled water at the temperature of maximum density, 39° ·2 Fahrenheit.

One kilogramme = 10 hectogrammes = 100 decagrammes = 1,000 grammes = 10,000 decigrammes = 100,000 centigrammes = 1,000,000 milligrammes.

(The French gramme = 15·4325 English grains.)

The Kilolitre is a cubic decimetre.

1 kilolitre @ 10 hectolitre @ 10 decalitre @ 10 litre @ 10 decilitre @ 10 centilitre @ 10 millilitre.

(The French litre = 1·76 Imperial pint, i.e. about 35 oz.)

The Metre, the unit of the entire system of weights and measures known as the metrical system, is assumed to be the 0·000010 part of the quadrant, or the 0·000040 of the whole globe measured over the poles.

1 metre (= 3·2808 feet or about 39 inches) = 10 decimetres = 100 centimetres = 1,000 millimetres.

1 metre = 0·1 decametre = 0·01 hectometre = 0·001 kilometre. 1 kilometre = 1093·633 yards.

1 Parisian foot = 1·0658 English foot.

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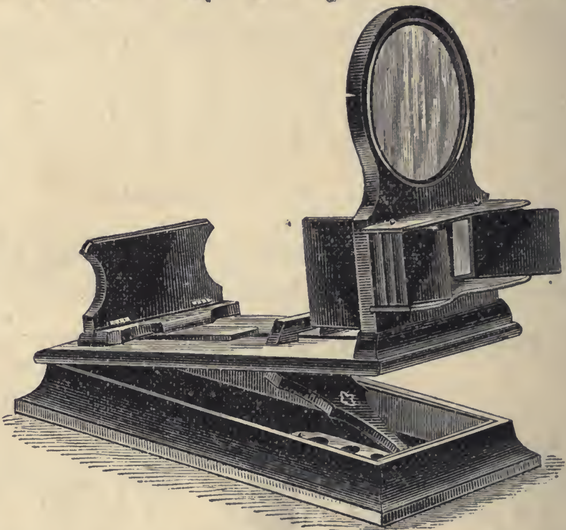

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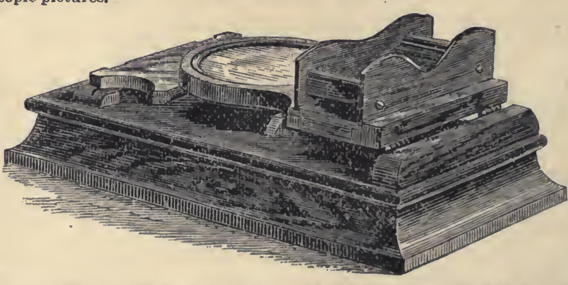

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